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ANNUAL REPORT

Northeastern Forest Experiment Station

Upper Darby, Pennsylvania
Ralph W. Marquis, Director

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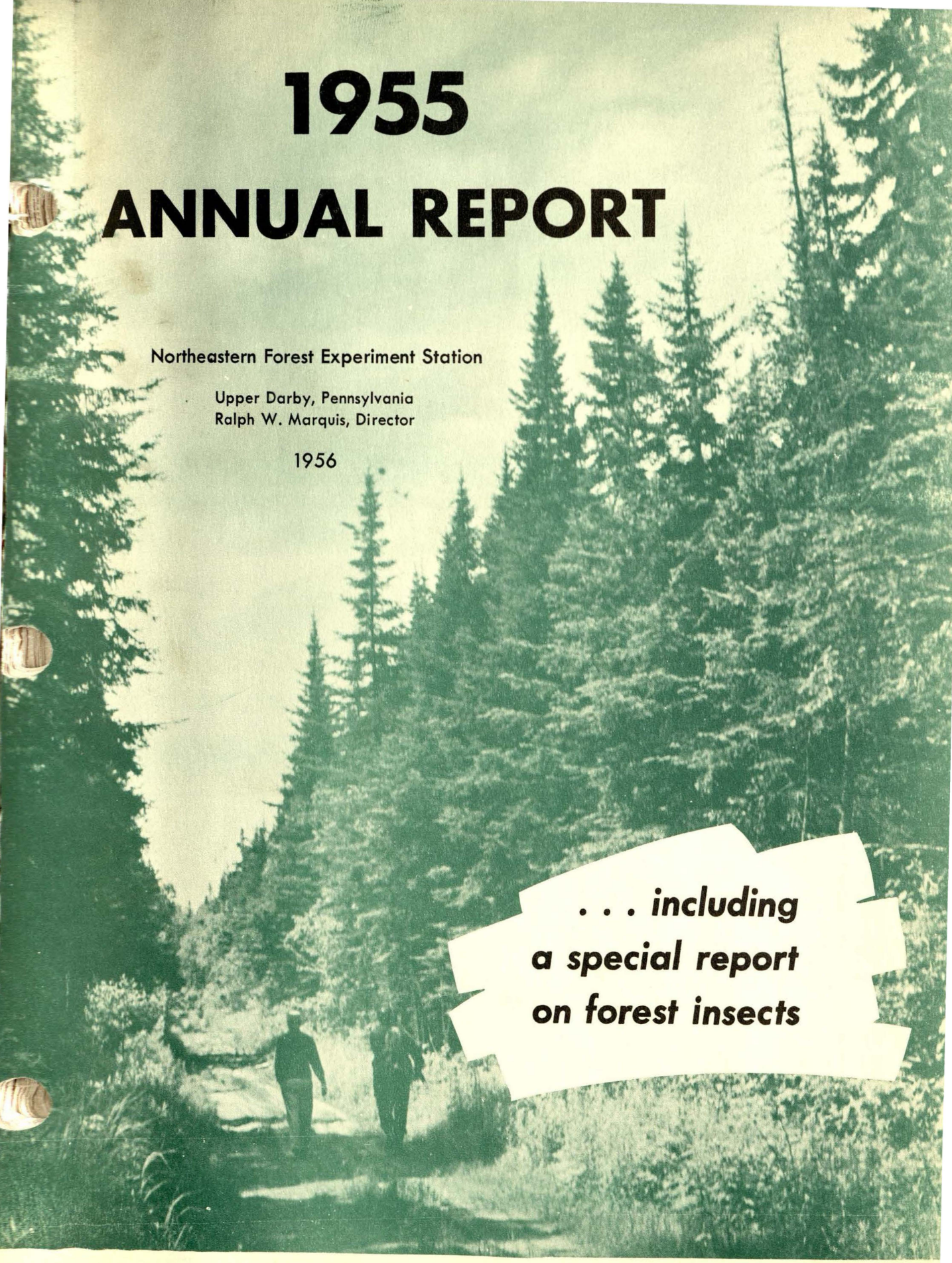

. . . including a special report on forest insects

Forest Service • • • United States Department of Agriculture

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1955

ANNUAL REPORT

OF THE NORTHEASTERN

FOREST EXPERIMENT STATION

INTRODUCTION

THE ANNUAL REPORT of the Northeastern Forest Experiment Station for 1955 again departs in some measure from the pattern of previous reports. This year, in addition to condensed reports of progress by the different divisions of the Station, we are presenting a more complete report on forest-insect research. The Division of Forest Insect Research as a part of the Experiment Station is relatively new, and the work done in the division may not be as well known to our readers as the other lines of work we have reported on for many years. Yet the work of this division ties in with almost all the Station's activities.

Emphasis On Insects

The Station program in insect research, as described in the following pages, follows rather traditional lines, and is realistic in terms of present knowledge and facilities. But this does not mean we are not aware of other possible means--some of them still in the realm of fantasy--of combatting injurious forest insects.

We have made some progress in a genetic approach to insect resistance, and there is evidence that there are differences in the resistance of different trees to insect attack. Whether this apparent resistance is inheritable must be determined. In the Northeast, the emphasis in this ap-

proach is on white pine and its possible resistance to white pine weevil attack. A search is being made for evidence of resistance in individual trees, in geographic races, in exotics of the white pine group, and in hybrid pines.

Associated with this approach is the need to know why some trees invite insect attack and others resist it. Is there a difference in chemical composition that explains this, and if so, can the attractive or repellent chemical be isolated? If this could be done, and if a means could be found to introduce the chemical into the tree economically, a new method of control could develop.

Advances in the use of atomic energy, some of them still classified, must be considered in relation to insect control. The success in combatting the screw-worm by sterilizing male flies through irradiation suggests the use of this method for controlling forest insects. Some progress has recently been made in killing forest-products insects, in situ, by lethal gamma rays. Can this method ever be applied safely and economically in the forest?

In the past, biological controls have been sought mostly through investigations of parasites and predators, but now greater emphasis is being given to studies of insect diseases. During the last few years some success has been attained in controlling sawflies by producing disease epidemics through the dissemination of virus organisms. Within the past year Agricultural Research Service scientists have discovered a virulent disease, associated with nematodes, which will attack a number of species of insects. The Station plans to expand its program in biological control with special emphasis on forest-insect diseases.

And finally we need better criteria for predicting outbreaks of forest insects. The Station's research program is designed to evaluate the role of biological factors and the effect of forest composition and condition in regulating insect populations. This information will serve to explain in part when, where, and if outbreaks may be expected. However, it often appears that there is some overshadowing influence, possibly weather, that transcends other factors in touching off insect outbreaks. In recent years Canadian entomologists and climatologists have produced some rather convincing evidence to show that outbreaks of certain forest insects are related to mass air movements. And while it is certainly presumptuous to think that man can "do anything about the weather", it would help greatly in planning control programs if it were possible, from a study of the influence of weather on insect abundance, to predict the occurrence of outbreaks by the major forest insects in the re-

gion. The Station plans to undertake studies in this field.

Much of this sounds like science fiction, but one must remember that the fantasy of a quarter century ago is becoming reality today.

People Make News

Appropriations, laboratories, and experimental forests do not produce research results, though they help immeasurably. It takes people to do research. So the personnel of an Experiment Station staff is of interest to those who look to it for new knowledge.

During the past year the Station has lost--through promotion, transfer, retirement, or change in interest--many productive researchers we would like to have kept. But we have also added a number of technical men with excellent research records and great promise. And we have made a few shifts to provide diversified training and to strengthen our organization.

John S. Boyce retired from his position in disease research. William Sopper and Harold Waddell left the forest-survey crew, the former to teach at Pennsylvania State University, the latter to work with industry. Thomas Church left forest-management research to help Jack Curry at Whitney Industries. Carl Holcomb left the Mountain State Research Center to become Extension Forester for Virginia. Milford Howard transferred from the Kingston Research Center to the Division of Recreation and Lands in Region 9 (Milwaukee). And Ivan Sims was promoted to the position of Staff Assistant, Branch of Research, in the Washington Office.

George Yelenosky, a graduate of Penn State, joined the forest-survey staff. Franklin Lewis and Arthur Hastings are new members of the forest-insect staff at New Haven. Grant Davis, from Region 6, is now at the Penobscot Research Center. Kenneth Reinhart left the Vicksburg Infiltration Project to work in watershed-management research at the Mountain State Center. Kenneth Pomeroy, formerly center leader at Lake City, Florida, is the new chief of our Division of Forest Management Research.

Intra-station transfers saw John Bjorkbom move from Upper Darby to Laconia, N. H.; Ted Grisez from Bangor, Maine, to Kingston, Pa.; Russell Hutnik from Laconia to Elkins, W. Va.; and Harold Huntzinger from survey to Kane, Pa. John McGuire was promoted to Chief of the Division of Forest Economics.

Five members of the Station staff are on educational leave: Henry Gerhold and Bill Waters at Yale, Ned Bethlahmy at Cornell, H. S. Potter at Maryland, and Henry Webster at Michigan.

Publication of research results continued at a good rate. Some 80 reports and articles were published in 1955; besides these, at year's end 34 reports of various sorts had been submitted to publishers and had not yet been published, and 9 reports were in the Station's printing plant ready for printing. An annotated list of the Station's 1955 publications appears in a later section of this report.

FOREST INSECT RESEARCH

FOREST-INSECT RESEARCH is a relatively new responsibility for the Forest Service. For many years this kind of research had been carried on by the Division of Forest Insect Investigations of the Bureau of Entomology and Plant Quarantine. When the Department of Agriculture was reorganized in January 1954, this function was transferred to the Forest Service.

This was done in the belief that the purposes and interests of the two agencies were so similar that the change would increase the effectiveness of both. The correctness of this belief has been demonstrated fully. Though the two agencies cooperated closely in the Northeast before the consolidation, the opportunities for fully integrated studies have been surprising.

Particularly striking is the community of interest in forest management and forest-insect research. For example, insects that attack white pine cones are an important factor in the regeneration of white pine. Activities of the white pine weevil may govern silvicultural treatments that foresters use to release white pine in mixed pine-hardwood stands; the weevil may dictate the choice of species for plantations. Forest management also serves as an effective means of reducing the damage done by some insects. In forest genetics, efforts are being made to discover strains or develop hybrids that will be naturally resistant to insect attack.

Disease research too is closely tied to insect research. The two often are closely associated, as in the beech scale-Nectria complex. Diseases of insects are one form of biologic insect control; and insects often act as agents that contribute to the spread of forest diseases. Insect damage is an important economic consideration: insects degrade forest products and they may dictate the intensities of management that forest owners can employ. Watershed research is concerned with the possible effects on water relations of any extensive killing of tree species.

A first step in the formal integration of forest-insect research into the over-all Station program was undertaken last spring when a conference was held to develop a program for research on white pine. The purpose of this was to bring together the knowledge and skills of all the Station's divisions. The contribution forest-insect research will make to this program will be substantial.

Although the following discussion of insect research presents the work of this one division, the reader will readily see that this work is closely related to other phases of the Station research program.

THE INSECT PROBLEM

Changes In The Forest Affect Insects

During the past 300 years a great change has taken place in the forests of the Northeast. The virgin forest that was here when the colonists came has been cut. A great deal of the land was cleared for agriculture, but later many farms were abandoned. Much of the forested area has been burned over, sometimes repeatedly; and wind storms and hurricanes have blown down quantities of timber. During the last half century large acreages have been planted with conifers, usually in pure stands. The forests of today differ greatly in composition and condition from those of the pre-colonial era. These changes have had a marked effect on the insect situation.

For example: The major forest insect of the spruce-fir forest is known as the spruce budworm, but its favorite host is balsam fir. Through the years, selective cutting for lumber and clear-cutting for pulpwood have reduced the spruce component of the spruce-fir stands and increased the proportion of fir. As this change in composition took place, outbreaks of the spruce budworm became both more frequent and more severe. This has undoubtedly been due to the ever-increasing proportion of balsam fir.

In the northern hardwood forest the forest tent caterpillar appears in outbreak proportions from time to time. One of the most favored food plants of this insect is poplar. Poplar frequently seeds in on burned areas after logging. There are much larger acreages of poplar now than there were before. Thus conditions for outbreaks of this insect are much more favorable today.

The continuous cutting and repeated fires in the white pine-transition hardwoods region of New England created a condition that led to the seeding-in of large quantities of gray birch and produced oak stands of poor quality. The gypsy moth, an European insect, has found such forest conditions ideal; and it has increased to epidemic proportions. This insect has repeatedly defoliated the hardwoods in this area. There is ample evidence that where forests are in good condition they are much more resistant to gypsy moth buildup.

The major insect enemy of white pine is the white pine weevil. In the early days most of the white pine grew in mixture with hardwoods. And, as we know from observations today, white pine growing under such conditions is weeviled to a much lesser degree than when it grows in pure stands in the open. But as the land cleared for agriculture was later abandoned, a great deal of white pine seeded in on the old fields and pastures. These open-grown stands were severely attacked by the weevil. This accounts to a large extent for the poor condition of the white pine stands today as contrasted to the better white pines of the Colonial era.

Much of the planting in the Northeast was done with little regard to possible insect damage, and many white pine plantations have been practically ruined by the weevil. Norway spruce plantings have also suffered severely from weevil attack.

But even when care was taken to avoid insect losses in establishing a new forest condition through planting, results have not always been too successful. Red pine was one species that was selected for extensive planting because it was believed to have few if any important insect enemies. But the European pine shoot moth practically ruined many plantations in Connecticut and states farther south. The Nantucket pine tip moth attacked plantations within its range. The sawflies, both native and introduced, defoliated large areas of red pine. And within the past 10 years a new enemy, a Matsucoccus scale insect, has been found in Connecticut and New York.

Foreign Pests A Big Problem

No forest region of the United States is afflicted with so many species of forest insects of foreign origin as is the Northeast. During the last century a large number of insects, mostly of European origin, have accidentally been brought into this region and eastern Canada through the channels of trade.

The gypsy moth, balsam woolly aphid, beech scale, European pine shoot moth, European spruce sawfly, several species of pine sawflies, the elm leaf beetle, European elm bark beetle, and larch sawfly--all of foreign origin--have become pests of major importance. Of lesser importance are the larch case bearer, birch leaf-mining sawflies, satin moth, browntail moth, Oriental hag moth, and willow leaf beetle. The recently discovered--and potentially dangerous--Matsucoccus scale on red pine may prove to be of foreign origin.

Discussion of a number of the most important of these introduced pests will appear in other sections of this report.

Insect Pests And Forest Types

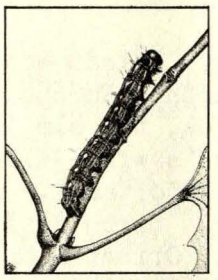
It is recognized that the classifications of forest types for a region may differ somewhat depending upon the purposes for which they may be used. For convenience in discussing the forest insects of the Northeast the region has been divided into six major forest types: spruce-fir, northern hardwoods, white pine-transition hardwoods, Allegheny hardwoods-hemlock, central hardwoods, and hard pine-oak. The Appalachian hardwoods of West Virginia have been included in the central hardwoods type. Coniferous plantations occur in all forest types.

Some of the insect pests of the region are confined mainly to a particular forest type because their principal food plants grow there. Others, which attack several tree species, may appear in two or more forest types.

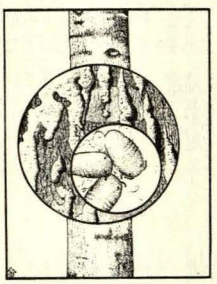
Forest insects damage trees in a number of different ways. Defoliators, as the name implies, feed on the needles or leaves of trees. Injury from defoliators is more damaging to conifers than to hardwoods: complete loss of foliage usually kills a conifer, but hardwoods may survive repeated defoliation. Defoliated hardwoods have the ability to develop a new crop of foliage in the same season; and though they may lose appreciable growth, the trees may continue to live. But if defoliation of hardwoods is coupled with some

SOME IMPORTANT FOREST INSECTS IN THE MAJOR FOREST TYPES OF THE NORTHEAST

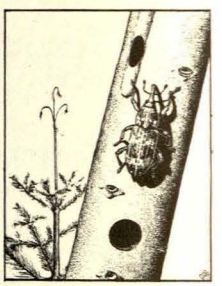
SPRUCE BUDWORM



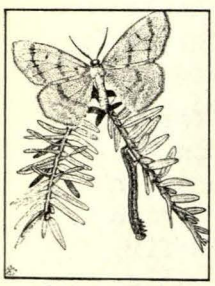
FOREST TENT CATERPILLAR



BEECH SCALE



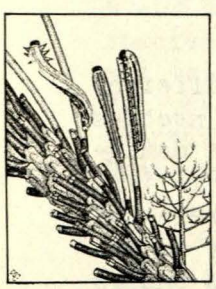
WHITE-PINE WEEVIL



HEMLOCK LOOPERS

GYPSY MOTH

SHOOT AND TIP MOTHS



PINE SAWFLIES IN PLANTATIONS

SPRUCE-FIR : *SPRUCE BUDWORM*

NORTHERN HARDWOODS : *FOREST TENT CATERPILLAR AND BEECH SCALE*

WHITE PINE-TRANSITION HARDWOODS : *WHITE PINE WEEVIL AND GYPSY MOTH*

ALLEGHENY HARDWOODS-HEMLOCK : *LOOPERS*

CENTRAL HARDWOODS : *PINE SAWFLIES IN PLANTATIONS*

HARD PINE-OAK : *SHOOT AND TIP MOTHS*

other debilitating factor such as drought, the trees may fail to survive even one complete stripping of foliage.

Sucking insects insert their mouthparts in the foliage or bark of trees and extract the fluids. The foliage becomes discolored and dies. Bark and phloem become dessicated and twigs and branches or the entire tree may be killed by girdling. Some sucking insects inject a poison into the tree, thereby increasing the injury. The puncture holes made by insects may serve as entrance for tree-killing fungi.

Other insects feed on or in (and kill) the shoots, twigs, or terminals of trees; this causes crooks or forks and loss in height growth without actually killing the tree. Some feed on the bark of young trees and kill by girdling. A number of species of insects attack and kill the cones or seeds of trees. Bark beetles feed in the inner bark of trees and kill by girdling. There are many species that bore in the wood of living trees and many that seriously damage forest products. Some are serious pests because they act as carriers of tree diseases.

Table 1 lists some of the most important insects in the different forest types, their principal food plants, and the type of insect, by feeding habit. More detailed information on these insects, their distribution, their appearance, life history, feeding habits, damage they do, and means of control will be found in the Appendix to this report.

Insect Damage Is Enormous

"Insects killed more timber than any other agency in 1952. They were responsible for 28 percent of the growing stock mortality and 10 percent of the national growth loss that year." So states the report on the Timber Resource Review, which was recently released by the U. S. Forest Service.

The forests of the Northeast can be classified into six forest types for purposes of forest-insect research. Some insects are limited to one particular forest type; some can be found in two or more. Some of the most damaging insects are pictured here. Map and drawings prepared by Paul A. Godwin, entomologist.

Table 1.--Important forest insects of the Northeast

Forest type	Insect	Principal host plant	Type of insect
Spruce-fir	Spruce budworm	Balsam fir, spruce	Defoliator
	European spruce sawfly	Spruces	Defoliator
	Hemlock loopers	Hemlock, balsam-fir	Defoliator
	Larch sawfly	Larch	Defoliator
	Larch case bearer	Larch	Defoliator
	Arbor vitae leaf miners	Cedar	Defoliator
	Balsam woolly aphid	Balsam-fir	Sucking insect
	Eastern spruce beetle	Spruces	Bark beetle
Northern hardwoods	Forest tent caterpillar	Poplar, maple, etc.	Defoliator
	Saddled prominent	Beech, maple, etc.	Defoliator
	Beech scale	Beech	Sucking insect
	Bronze birch borer	Birches	Borer
White pine -transition hardwoods	White pine weevil	White pine, Norway spruce	Terminal feeder
	Gypsy moth	Oaks, birch, etc.	Defoliator
	Pales weevil	White pine, other conifers	Bark feeder
	Cone insects	Conifers	Cone & seed feeder
	Pine leaf aphid	White pine, spruce	Sucking insect
	Pine looper	Pitch pine, red pine	Defoliator
	Hemlock looper	Hemlock	Defoliator
	Hemlock looper	Hemlock	Borer
Allegheny hardwoods -hemlock	Cankerworms	Oak, elm, etc.	Defoliator
	Hemlock looper	Hemlock	Defoliator
	Hemlock borer	Hemlock	Borer
	Pit-making oak scale	Chestnut oak	Sucking insect
	Walkingsticks	Oak, cherry	Defoliator
Central hardwoods	Cankerworms	Oak, elm, etc.	Defoliator
	Hemlock looper	Hemlock	Defoliator
	Hemlock borer	Hemlock	Borer
	Pit-making oak scale	Chestnut oak, white oak	Sucking insect
	European elm bark beetles	Elm	Carrier of Dutch elm disease
	Elm leaf beetle	Elm	Defoliator
Hard-pine-oak	Pine looper	Pitch pine, red pine	Defoliator
	Nantucket pine tip moth	Hard pines	Twig & terminal feeder
	European pine shoot moth	Hard pines	Twig & terminal feeder
	Pine sawflies	Virginia & loblolly pines	Defoliator
Coniferous plantations in all forest types	White pine weevil	White pine, Norway spruce	Terminal feeder
	Matsucoccus scale	Red pine	Sucking insect
	European pine shoot moth	Hard pine	Twig & terminal feeder
	Spittle bug	Pine	Sucking insect
	Pales weevil	Conifers	Bark feeder
	Pine sawflies (several species)	Pine	Defoliator
	Pine leaf aphid	White pine, spruce	Sucking insect
	European spruce sawfly	Spruces	Defoliator
Forest products	Termites	--	--
	Powder post beetles	--	--
	Old-house borer	--	--

The Review mentions that one insect-caused "catastrophe" occurred in the Northeast; namely, the spruce budworm epidemic in Maine during 1910 to 1919, when 8 billion board feet of spruce-fir timber was killed. The Northeast also has the rather dubious distinction of having the Nation's most expensive forest insect, the gypsy moth, which in 1952 cost $1,772,000 for direct control.

The Review includes estimates, obtained in large part from information supplied by state cooperators, of mortality and growth loss caused by insects in 1952. The losses in our Northeastern States were as follows: for growing stock, a mortality loss of 31 million cubic feet and a growth loss of 102 million cubic feet; for sawtimber, a mortality loss of 77 million board feet and a growth loss of 263 million board feet. For losses caused by certain insects, the 1952 figures represent the average annual losses over a period of years.

The insects that were responsible for the greatest losses in the Northeast were the white pine weevil, gypsy moth, balsam woolly aphid, forest tent caterpillar, and eastern spruce beetle.

THE BASIS FOR CONTROL WORK

To find ways to control these insects that do such great damage to the forests of the Northeast, we must have much basic information about their life histories and habits, their food-plant preferences, factors that affect their abundance, and so on. And to develop adequate control programs we must devise ways of locating insect outbreaks, and ways of detecting the presence of new pests. To do this, forest-insect surveys are needed.

Forest-Insect Surveys

Forest-insect surveys are of different types. Detection surveys are made for the purpose of locating outbreaks of pests of known economic importance or the presence of new pests. When an outbreak is discovered and it seems that control might be needed, appraisal surveys are made to determine precisely the extent and nature of the outbreak and whether (from entomological considerations) control should be recommended. Damage surveys are made to obtain estimates of the losses that result from insect attack. Such surveys are important not only for obtaining an inventory of the destruction caused by insects, but also for establishing priorities for research programs. Then too, there are research surveys. These are made to determine insect-population trends over a period of years. Such surveys result in a better understanding of the development of insect infestations under different forest conditions.

Forest-pest surveys received a great impetus with the passage of the Federal Forest Pest Control Act in 1947, which recognized federal responsibility in conducting surveys on lands in all classes of ownership. Since that time

MAINE FOREST SERVICE PHOTO

Insects cause enormous losses in our forests every year. This spruce-fir stand was killed in the 1910-19 spruce budworm epidemic. That epidemic destroyed 8 billion board feet of timber in Maine alone.

great progress has been made not only in developing and conducting surveys, but--even more important--in developing a spirit of cooperation between federal, state, and private agencies to work together toward a common goal.

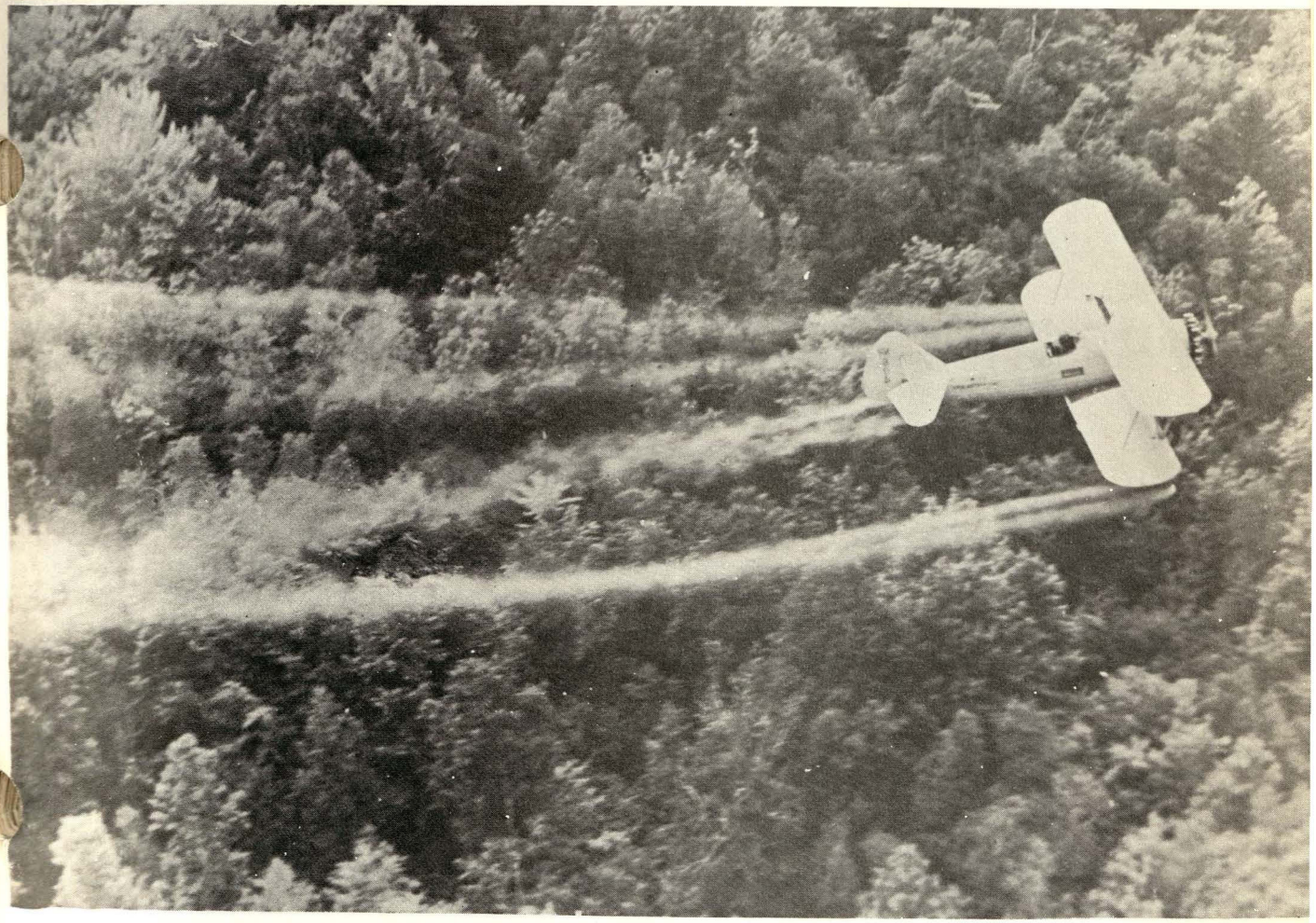
Perhaps the greatest step forward in the past few years, in keeping track of forest pests, is the progress that has been made in aerial surveys. It is now common practice to survey the forests of an entire state to determine the status of a forest pest. Trained observers, using specially designed recording devices, can prepare accurate maps showing the location, extent, and even intensity of an outbreak. Colored aerial photographs are also being used effectively for surveys of some pests. Of great importance, but less spectacular, have been the improvements in methods and techniques for conducting ground surveys.

Advances in control methods (notably airplane application of insecticides, and chemical treatment of bark beetle infested trees) have made surveys much more meaningful than before. Now, with assurance of success, we can tackle control jobs that a few years ago would have been either hopeless or totally impractical.

Here in the Northeast the states are carrying the major load in forest-insect-survey work. States like Maine, New York, and Pennsylvania, for example, have excellent survey programs already in operation. Other states are developing programs. All states are making valuable contributions in detecting and reporting forest-insect outbreaks.

Forest-insect control is costly. About 1½ million acres were sprayed by aircraft in New England and New York in 1954 to combat the gypsy moth and prevent its spreading.

NEW YORK CONSERVATION DEPARTMENT PHOTO



The Station is cooperating with the states by assisting on surveys and attempting to coordinate the work between states in order to obtain a more uniform regional program. It serves in some measure as a clearing house for collecting and disseminating information on the status of forest insects. And it is carrying on research to develop and improve survey methods and techniques.

Control Is Everyone's Responsibility

The objectives of forest insect control are several: to prevent damage to growing timber and to forest products; to protect areas of high scenic and recreational value; to protect watersheds; and to prevent soil and site deterioration which might result from defoliation and death of trees.

Forest-insect surveys are not goals in themselves; they are made to establish a basis for control work. But there is a further requirement for effective control work: this is full cooperation among private industry and state and federal agencies.

Basically the states are responsible for controlling forest insects on state-owned land. They also recognize a responsibility to cooperate in insect-control programs with private landowners. To do this they should have the proper legal authority to conduct surveys on private lands and to enter into cooperative control projects with private landowners and with the federal government.

The federal government has a responsibility, as defined in the Forest Pest Control Act, in the control of forest pests on lands in all classes of ownership. It is the sole responsibility of the federal government to control forest insects on nationally owned lands.

When control actions on non-federal lands are considered, the forest experiment stations have a responsibility to collaborate with state officials in determining whether control should be recommended on the basis of entomological considerations, and to supply technical information on control methods. When federal control funds are involved, the forest experiment stations provide technical advice on control and assist in determining the results of control measures.

When federal funds are involved in control measures on state or private lands, the regional offices of the Forest Service, in collaboration with state officials, determine whether the control program is economically sound.

A review of a recent control project may serve to illustrate how all the different interested persons and agencies pool their efforts in a cooperative program. In 1953, cooperative surveys conducted by entomologists from the Maine Forest Service and from this Station revealed an outbreak of the spruce budworm on intermingled privately-owned and state-owned land in northern Maine. The intensity of the outbreak (and the fact that, as studies showed, it was not likely to be controlled by biological factors) led to the conclusion that direct control was needed. Furthermore the outbreak, which covered about 20,000 acres, was a menace to millions of acres of valuable timber in northern Maine.

A recommendation was made jointly by Maine timberland owners, the Maine Forest Service, and the Northeastern Forest Experiment Station entomologists that this area be sprayed in the spring of 1954. The Maine Forest Commissioner requested federal assistance in financing the project. It was approved by the regional office of the Forest Service; and a control project was set up under the Forest Pest Control Act. The federal government contributed 25 percent of the cost of control and the Maine timberland owners and the State jointly provided the balance. The Forest Service regional office worked out the administrative details with the Maine Forest Commissioner. Entomologists from the Northeastern Forest Experiment Station and the Maine Forest Service worked together as a team in giving technical advice on the control operation and in evaluating the results.

PROGRESS IN INSECT CONTROL

There are three different methods that may be used in combatting forest insect pests and reducing the damage done by them: biological, chemical, and silvicultural. However, before these methods may be effectively employed it is necessary to obtain much basic information about the insect itself.

First its identity must be established, not only in the adult stage but also in the immature stages. Usually it is the immature stage that causes the damage. Then its food plant preferences, its life history and habits, its distribution, and its importance as a pest must be determined. Finally, the effect of natural factors (both physical and biological) on the insect and its survival should be investigated.

Over a period of many years entomologists in the Northeast have obtained a great deal of basic information about a large number of forest insects. The results of

these studies have appeared in numerous publications. Much of this information was recently assembled and published in F. C. Craighead's book, INSECT ENEMIES OF EASTERN FORESTS (U. S. Dept. Agr. Misc. Pub. 657; 679 pp., illus., 1950).

With this basic background information about an insect it is possible to explore intelligently the possibilities of control by biological, chemical, or silvicultural methods.

Biological Control

The term "biological control" owes its origin to the fact that most injurious insects are attacked by parasites, predators, and diseases. There are hundreds of native species of potentially injurious insects in the forest; but the great majority of them are continually held in check by their natural enemies. This is what is meant by the "balance of nature." Sometimes, and for reasons that are not fully understood, this natural balance is upset: the population of one or more of the forest insects increases to the epidemic stage; and an outbreak ensues.

A serious problem arises when an insect of foreign origin becomes established in our forests without its natural enemies. But man can employ biological control tactics to combat the foreign invader. He can go to the native habitat of the pest and collect, rear, and ship to this country its parasites and predators, and colonize them here in infestations of the introduced pest. Much of this type of work has been done in the Northeast and in Canada to combat the numerous forest insects of foreign origin that have become established here. Sometimes an opportunity occurs to aid in the biological control of a native pest by shifting parasites or predators from one area in the United States where they are present to another area where they are absent.

Biological control work on the gypsy moth in New England is world-famous. Most of the important natural enemies of this insect were brought from Europe and established here. They have spread throughout most of the infested area, and in much of the region they are exerting a degree of control that is comparable to that in Europe. This work on the gypsy moth was a pioneer undertaking. The methods and techniques that were developed for handling parasites and predators helped lay the foundation for much of the later work that has been done in this field.

Perhaps the most striking case of complete control of an introduced forest insect was that of the European spruce sawfly. In the '30s severe outbreaks of this insect oc-

curred in eastern Canada and in New England. The Canadians initiated a vigorous and extensive parasite-introduction program to combat this sawfly. They succeeded in establishing seven species of parasites. One small cocoon parasite, Dahlbominus fuscipennis Zett, which could be easily reared in the laboratory, was produced in large numbers. All together, the Canadian Government and some of the Northeastern States--particularly Maine--reared and liberated more than a billion of these cocoon parasites. Suddenly, between 1940 and 1943, the heavy sawfly infestations over the entire region were reduced to a very low population level by a virus disease. The origin of the disease is unknown, but it is suspected that it was introduced from Europe with the parasite material. The sawfly has since been held in check by the virus disease and the introduced parasites.

An example of how biological control techniques may be used against a native forest insect may be illustrated by recent work on the spruce budworm. There are several parasites of the budworm that are present in the West but not in the East. During the last few years strenuous efforts have been made to establish these parasites in the East. One western larval parasite, Phytodietus fumiferana Roh, is being reared at the Maine Forest Service Laboratory in Augusta. It is difficult to rear, but some good colonies have been liberated in northern Maine.

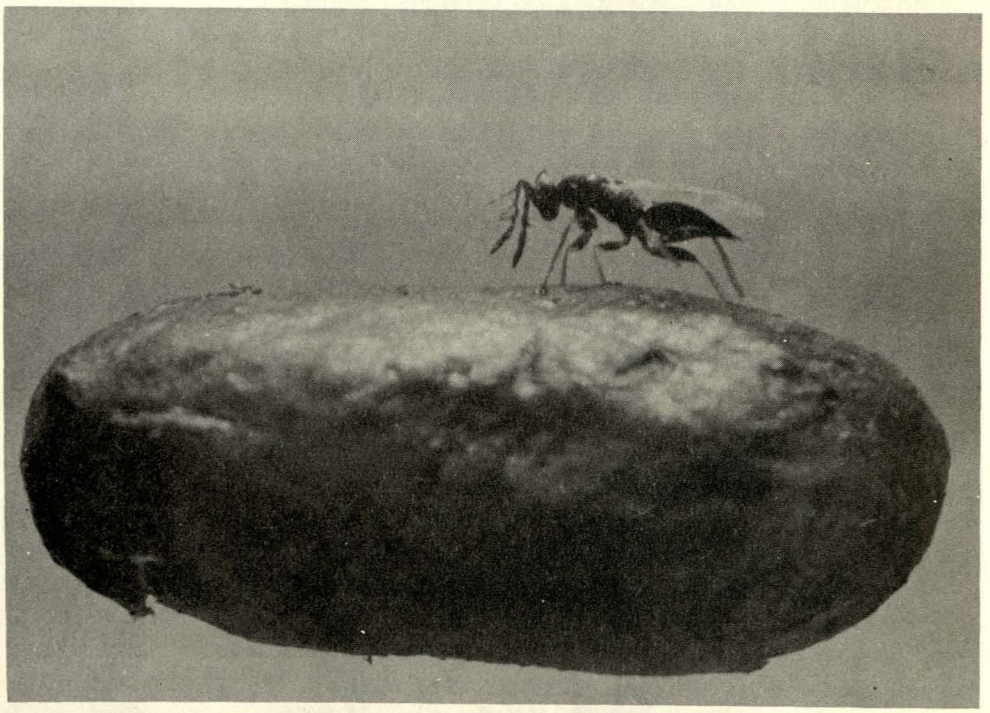
Biological control factors are sometimes used as direct control agents. Recent work with disease organisms seems to be opening up new and potentially important possibilities in this field. Excellent control of the European pine sawfly (Neodiprion sertifer Geoff.) has been obtained by disseminating a virus disease of this pest. A dilute suspension of the virus in water is applied as a spray from ground equipment or from an airplane. On the other hand, the mass rearing and release of insect parasites has not been generally successful. This is undoubtedly due to the fact that if the parasites are already present they will increase naturally about as rapidly as conditions permit, and additional releases are not effective.

The utilization of a new and entirely different method of biological control recently developed by entomologists in the Agricultural Research Service has resulted in the eradication of the screw-worm, an insect that attacks cattle, on the island of Curacao in the West Indies. Research showed that screw-worm males (and females) could be made sexually sterile by exposing pupae to irradiation--and without serious effects on the mating behavior of the insect. The research also showed that the female screw-worm fly mates only once during her lifetime, and if mated to a sexu-

ally sterile male her reproductive potential is completely destroyed. It remained to be shown that the principle could be used under field conditions, and that a high proportion of wild females would mate with sterile males when sterile males predominated. Sterile males were reared in large numbers and released from airplanes. The exact ratio of released sterile males to wild fertile males at the start of the experiment was unknown, but it probably ranged between 2 and 4 to 1. Within about 3 months (about three generations) the screw-worm was eliminated. Although a number of rather special requirements are essential, the soundness of this new method has been established. There may well be possibilities for its use in combatting forest-insect pests.

Foreign species of forest insects usually arrive here without their natural enemies; so entomologists sometimes import predators and parasites and sic them on the insects. This tiny parasite *(Dahlbominus fuscipennis)*, shown here attacking a cocoon of the European spruce sawfly, was imported from Europe. More than a billion of these parasites have been released in the Northeastern States and Canada to combat the sawfly.

MAINE FOREST SERVICE PHOTO



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MAINE FOREST SERVICE PHOTO

A Maine Forest Service warden releases cocoon parasites *(Dahlbominus fuscipennis)* beneath a spruce tree. The cage contains a colony of 10,000 parasites. These parasites--along with a virus disease--have held the spruce sawfly in check.

The importance of biological control as a means for combatting forest insects cannot be over-emphasized. This is a type of control that is self-perpetuating; and in the long run it is undoubtedly the least expensive of all control methods. It is true that one can seldom expect to obtain such complete control of an insect as in the case of the European spruce sawfly, but one may expect that biological-control agents will help in prolonging the period between outbreaks of an insect and in lessening the impact of an outbreak when and if it does occur. Thus every effort

A mass of dead European spruce sawfly larvae, killed during the virus disease epidemic of 1940-43, which wiped out all outbreaks of the sawfly in this country and in Canada. It was estimated that there were some 80,000 dead larvae on the ground at the base of this spruce tree in Vermont.

should be made to explore thoroughly the possibility of utilizing this method of control for forest-insect pests.

Chemical Control

The advances in chemical control of forest insects during the past 15 years have been outstanding. Prior to about 1940, dilute lead arsenate spray applied with a hydraulic sprayer was the most effective method. One machine with a crew of men to carry hose could spray about 200 acres of accessible woodland in a field season at a cost of $20 to $100 per acre, depending on the length of the hose line. Today, with a multi-engined airplane using DDT, it is possible to spray 1,000 acres in 10 minutes at a cost not exceeding $1 per acre, and with assurance of almost complete control of many forest defoliators.

A great deal of research preceded the aerial-spraying feats of today. Before DDT was discovered, lead arsenate was prepared in highly concentrated form and was dispersed from airplanes and autogiros with specially designed spray-

ing devices. Using one of these spraying devices, DDT was first applied by an airplane for forest-insect control here in the Northeast when, in 1944, a 20-acre area of gypsy-moth-infested woodland in Pennsylvania was sprayed. The dosage used was 5 pounds of DDT in 5 gallons of spray per acre. It was later found that 1 pound of DDT in 1 gallon per acre was just as effective; and that has become the standard dosage for control of most forest defoliators. And, under most conditions, this 1-pound-per-acre dosage has no adverse effect on birds, fish, or other wildlife in the forest.

Basic research in airplane spraying was conducted at the Beltsville Forest Insect Laboratory. That laboratory is cooperating with the forest experiment stations in airplane spraying tests for the control of the spruce budworm and other forest insects. Many carefully planned field tests were required to work out such details as proper timing of spray applications to coincide with the most vulnerable stage of the insect, formulation and dosage of spray, droplet size, width of swath, and height above tree tops for spray release.

The information gained in these tests has made it possible to control outbreaks of defoliators over millions of acres of forest. Both fixed-wing planes and helicopters have been used successfully. For some operations, helicopters have advantages over fixed-wing planes: slower speed, close-to-ground maneuverability, and a down-draft effect that helps to deposit the spray.

Unfortunately some types of forest insects are not so easily controlled by aerial spraying with DDT. Much heavier dosages are required to control the white pine weevil. It is possible to obtain only partial control of the European pine shoot moth even with heavy dosages. Bark beetles and some other types of insects cannot be controlled by aerial spraying at all.

The invention of the mist blower was a notable step forward for applying chemical sprays from the ground. The largest machines are capable of dispersing finely atomized spray to the tops of the tallest shade trees. With such a machine it is possible to obtain satisfactory coverage of a large tree with only a quart of spray material. With a hydraulic sprayer, 20 to 30 gallons of spray would be required. Smaller sized machines have been constructed, the latest being a knapsack model. Mist blowers are being used extensively for controlling insects on shade and ornamental trees along streets and highways and in parks and recreational areas. They are being used in forest nurseries and planta-

tions for combatting insect pests. Recently a mist blower, mounted on a tractor, was used for dispersing herbicides to kill hardwood sprout growth and release white pine growing in the understory. There are many uses for mist blowers outside the field of forest-insect control.

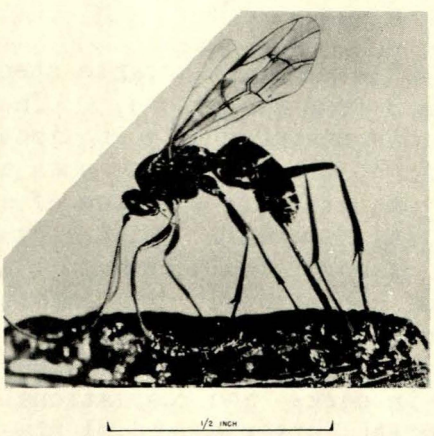
Improvements have been made in other types of spraying equipment and in devising special uses for such equipment. For example, by using a special atomizing nozzle and an extension rod on the conventional knapsack sprayer, an effective method was developed for applying concentrated sprays for white pine weevil control.

During recent years the chemical industry has produced many synthetic compounds that have insecticidal properties. They have been tested for the control of many forest insect pests, and excellent results have been obtained with a number of them. Most of them have been used as stomach or contact poisons.

Another possible method of controlling insects is by introducing into the sapstream of a living tree certain chemicals that will be toxic or repellent to insects that feed on the tree. Such chemicals are called "systemics." They may be introduced into the sapstream either by injection, by treating the soil, or in some cases by spraying the foliage. Only exploratory work has been done in this field, but enough to encourage us to probe deeper. This method offers promise for combatting those species of insects that are difficult or impossible to control by the more conventional methods.

Silvicultural Control

The objective of silvicultural control is not to kill forest insects, but to reduce the damage they do. By changing the composition or condition of a forest stand, damage may be eliminated or reduced. This is done by removing trees before they are



This parasite *(Phytodietus fumiferana)*, a native of the West, is being reared in the Northeast to combat the spruce budworm. It attacks the larva, as this adult is shown doing here.

MAINE FOREST SERVICE PHOTO

Spruce budworm parasites *(Phytodietus fumiferana)* are being reared by the Maine Forest Service in its laboratory at Augusta, Maine. This parasite is difficult to rear, but some colonies have been released in budworm-infested forests in northern Maine.

attacked, by salvaging infested trees or stands before they deteriorate, or by increasing the resistance of a stand to insect attack.

The first of these methods may be used in cutting spruce stands before they become overmature, for the eastern spruce beetle attacks only overmature trees. Damage from the budworm in mixed spruce-fir stands can be reduced by removing the mature fir; and damage in pure balsam fir stands can be cut down by operating such stands on short cutting cycles.

Sanitation cuts can result in getting maximum economic value out of a stand. When populations of the beech

scale or balsam woolly aphid build up to epidemic proportions, for example, the stand should be harvested before the trees are killed and begin to deteriorate.

There are a number of ways in which the resistance of a stand to insect attack may be built up. Attack by the white pine weevil may be reduced greatly by growing white pine in mixture with hardwoods. Woodlands may be made more resistant to gypsy moth build-up by avoiding excessive cut-

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Development of aerial-spraying methods has made large-scale control projects possible. A plane like this converted B-17 can spray more than 1,000 acres in 10 minutes. This plane is spraying for gypsy moth control in Massachusetts.

WORCESTER TELEGRAM GAZETTE PHOTO BY E. A. COURNOYER

ting, by encouraging tree species that are not favored food plants of the insect, and by generally improving conditions in the forest through fire protection.

There is usually no conflict between silvicultural control and good forest management. Generally speaking, a mixed forest is more resistant to insect attack than a pure stand of one tree species. In a forest that is composed of a variety of tree species and harbors a number of insect

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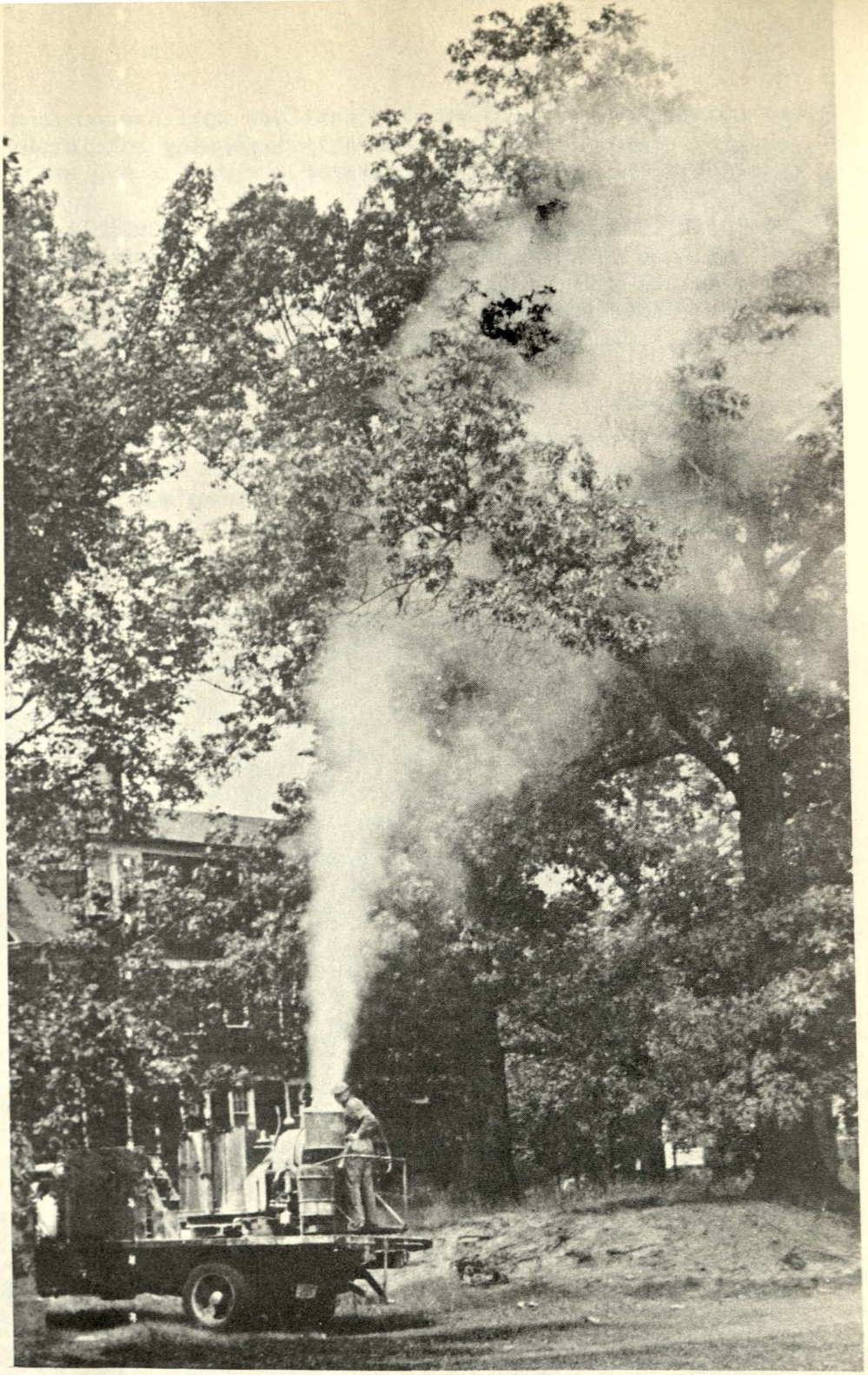
Helicopters, being very maneuverable at low speeds and low altitudes, are superior to fixed-wing planes for some spraying operations. This helicopter is spraying a particularly difficult area for gypsy moth control.

NEW ENGLAND HELICOPTER SERVICE PHOTO



CONNECTICUT AGRICULTURAL EXPERIMENT STATION PHOTO

Spraying tall shade trees with a large mist blower. The mist blower is rapidly replacing the hydraulic sprayer for combatting insect pests on shade and ornamental trees.

pests, the population of any specific insect on a specific host plant is much less concentrated than in a pure stand. Furthermore, a mixed forest is much more favorable for parasites and predators, particularly those species that prey upon more than one insect species. Most silviculturists agree that the mixed forest is desirable from an ecological viewpoint.

In the Northeast, where nature has provided such a wide variety of tree species, there should be excellent opportunities for developing silvicultural control methods. This field needs thorough exploration; for this type of control, along with biological control, is lasting as contrasted to chemical control, which reduces the insect population for the moment but leaves the forest as susceptible as before.

The latest development in mist blowers is the knapsack type, which can be carried into places where the larger machines cannot go. It may become a competitor of the conventional knapsack sprayer.

Spraying methods, materials, and equipment are tailored to the individual insect. To protect white pine trees from the white pine weevil, the leaders are sprayed with lead arsenate. A conventional knapsack sprayer, fitted with an extension rod, can be used to treat trees up to 12 feet high.

PROBLEMS THAT FACE US TODAY

Some of the forest-insect problems that face us today in the Northeast are general in nature, involving a large number of insect species. Others are specific, problems of particular insects that are currently causing concern. The problems of the forest entomologist are in a continual state of flux. New insect pests appear. Others that have been

innocuous suddenly become epidemic and demand attention. And others that may have been of great concern become quiescent.

General Problems

Detecting outbreaks of forest-insect pests is one of our most important problems. To combat insect pests effectively, outbreaks should be discovered and reported when they are small so that prompt control action may be taken.

To properly evaluate outbreaks we are confronted with the problem of determining the status of natural factors of control as a basis for determining the need for chemical control.

Important progress has recently been made in the chemical control of forest insects. New insecticides are appearing regularly, and entomologists are confronted with the task of formulating, screening, and testing these materials against a variety of insects. There is a constant need for developing and improving equipment for applying insecticides. It is important that land-managing agencies and the general public be kept up to date on forest insects and methods for controlling them. Thus we have a continuing problem of education and dissemination of information.

Specific Problems

Some of the current major insect problems in the different forest types are as follows:

Spruce-fir.--The spruce budworm continues to be a major problem in Maine because the light to moderate infestation that persists throughout the northern part of the State may increase to outbreak proportions; and the threat of a mass moth flight from the Canadian provinces of New Brunswick and Quebec will continue as long as heavy outbreaks persist there. The balsam woolly aphid is apparently increasing in Vermont and New Hampshire and is causing widespread mortality of balsam fir in Maine.

Northern hardwoods.--The beech scale and the accompanying Nectria fungus have caused widespread destruction of beech in Maine; and tree mortality is now becoming heavy in portions of the White Mountains in New Hampshire and the Catskills in New York. Heavy outbreaks of the scale and Nectria were found in Vermont last year for the first time. The forest tent caterpillar and the saddled prominent are currently epidemic in the northern hardwood forest.

White pine-transition hardwoods.--The white pine weevil is continually causing losses in volume and lowering the

quality of white pine in the Northeast. The Pales weevil is a perennial pest of coniferous seedlings on cut-over and burned-over pine land. Last year it was discovered that cone insects completely destroyed the white pine seed crop in one area in Maine. The gypsy moth periodically defoliates vast areas of hardwoods. Great sums of money are expended annually to control this insect and prevent its spread.

Central hardwoods.--The pit-making oak scale is suspected of causing widespread mortality of chestnut oak. The oak wilt disease may be transmitted by insects.

Hard pine-oak.--The European pine shoot moth and the Nantucket pine tip moth are perennial pests of hard pines in this forest type. Last year heavy outbreaks of the pine looper occurred in Massachusetts, Connecticut, and Delaware. Heavy outbreaks of pine sawflies in Maryland have occurred in recent years.

Coniferous plantations in the Northeast.--The Matsucoccus scale is potentially the most serious threat to planted red pine. Other important enemies of red pine are sawflies, shoot and tip moths, and spittle bugs. The most important insect problem in white pine plantations is the white pine weevil. This weevil is also a serious enemy of Norway spruce. Current outbreaks of pine leaf aphids and spittle bugs occur in white pine plantings.

Forest-products insects.--Termites, powder post beetles, and the old-house borer are the principal forest-products insects of the region.

These Problems Guide

The Research Program

Each year we are faced with the problem of obtaining information on the current status of the major insect pests of the region. Specific surveys are conducted for some, followed by recommendations for or against control. Technical advice on control may be needed. The problems in research differ considerably for the different insect species. For some, additional basic information on biology and ecology is needed. For others emphasis must be given to biological control. And for still others we must explore the possibility of control by chemicals. Sometimes investigations are needed in all research categories for a particular insect.

THE STATION'S RESEARCH PROGRAM

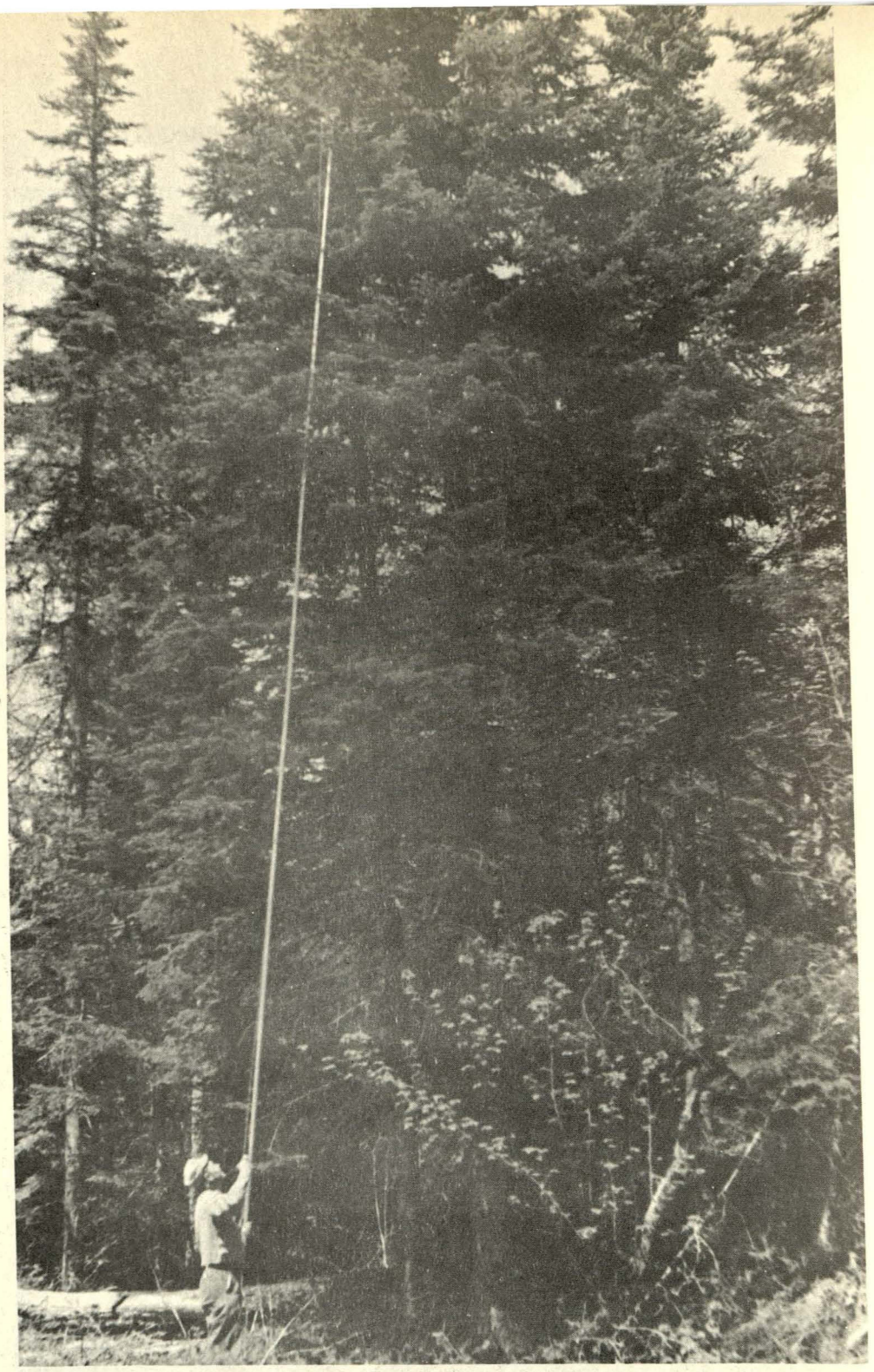
The Northeastern Forest Experiment Station's program of forest-insect research is carried out by its Division of Forest Insect Research. The center for this work is the Forest Insect and Disease Laboratory, which the Station maintains at New Haven, Connecticut.

The work of the division falls into four major categories or projects: (1) surveys, (2) biology and ecology, (3) biological control, and (4) chemical control. Though technical personnel are assigned to each of these projects, the Laboratory operates as a team so there is considerable interchange of personnel between projects.

Surveys

The survey program is designed to assist the states in their survey work and to conduct research on survey methods and techniques.

The experiment station's Forest Insect and Disease Laboratory at New Haven, Connecticut, is the center for federal forest-insect research in the Northeast.



Sample twigs are taken from balsam fir trees to determine the population of spruce budworm. A 40-foot telescoping aluminum pole pruner is used in this work. Surveys are made every year to determine the seriousness of the budworm situation.

Spruce budworm surveys are conducted each year in cooperation with the Maine Forest Service to determine the population of larvae and pupae, the extent of defoliation, and the egg-mass population.

Special surveys are conducted each year for certain pests that may be causing current concern. For example, in 1955 members of the Laboratory staff participated in surveys for the pine looper in Massachusetts and Connecticut, for pine sawflies in Maryland, for the beech scale in Vermont, for Matsucoccus scale on red pine in Connecticut, and for the saddled prominent in Massachusetts. Reports were prepared giving the results of each survey, an appraisal of the situation, and recommendations for control if needed.

Plans are now being made for a cooperative survey with the State of West Virginia in 1956 to determine the status of tip and shoot moths in the red pine plantations in that state. We also plan to cooperate with some of the states in an examination of white pine weevil research plots that the states have established during recent years to determine population trends of the weevil. Technical advice and assistance, if possible, will be given to the New England States in connection with the establishment of study plots to determine population trends of the gypsy moth. Before the beginning of the next field season, plans for surveys on other insects will be made.

An effort will be made in 1956 to develop a system for periodically collecting and disseminating information throughout the region on the current status of forest-insect pests. This will be in addition to the annual compilation on forest-insect conditions in the Northeast.

In research on survey methods, studies will be continued to extend the use of the sequential system of sampling. By this method, which is used to determine different levels of population density, with a minimum of sampling, a great saving in time and effort was effected for forest tent caterpillar and spruce budworm egg-mass surveys. Its use for sampling populations of other insect species will be explored. Studies of the possibility of using colored aerial photography for white pine weevil surveys will be undertaken.

Biology And Ecology

Studies are under way to evaluate the natural factors that affect the spruce budworm in northern Maine. These studies have been going on since 1948; and they have helped immeasurably in evaluating the budworm situation with re-

spect to the needs for direct control. They will be continued until the threat of a budworm outbreak is over.

Much basic information on the biology, habits, and ecology of the white pine weevil is needed as a basis for developing control methods. The present research program, designed to supply this information, involves studies of the egg-laying habits of the insect; the effect of physical factors such as temperature and humidity, and biological fac-

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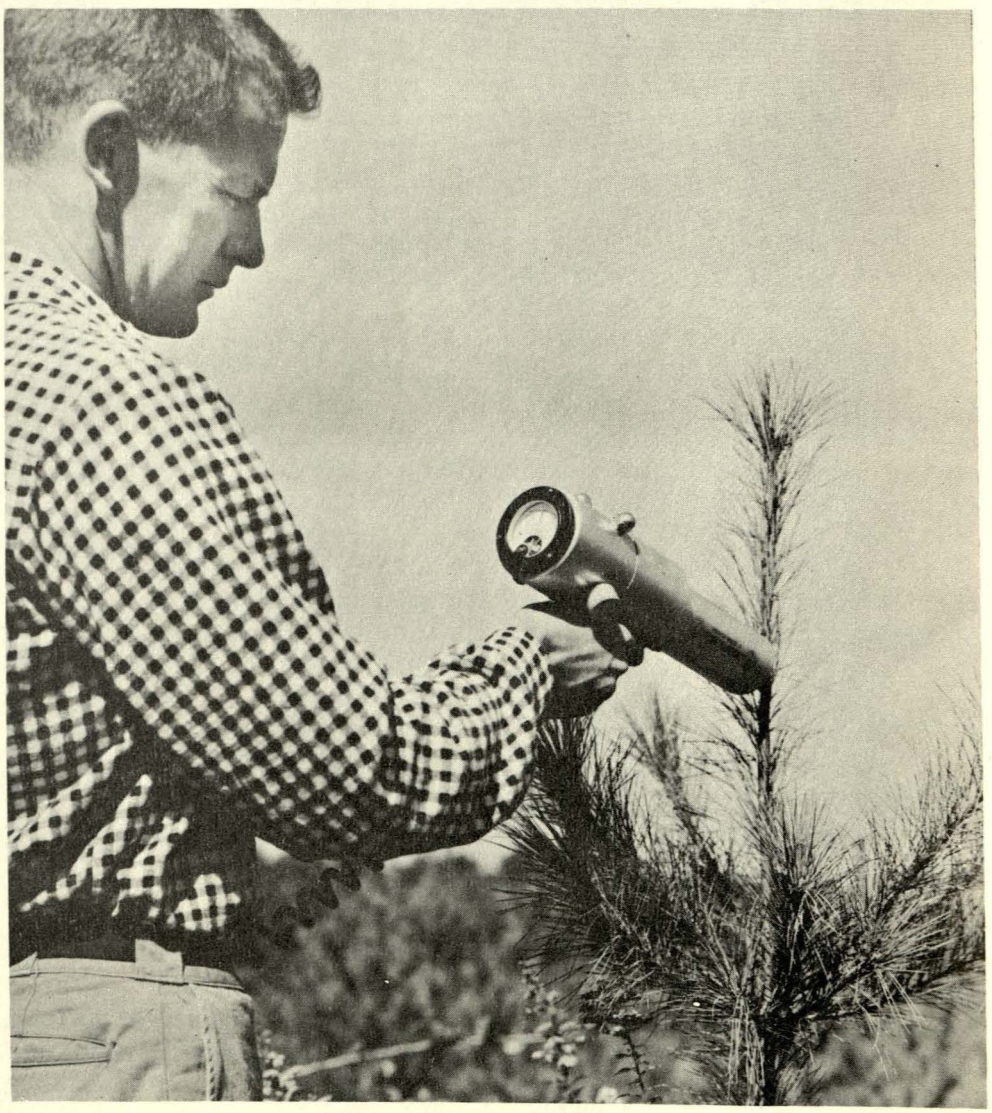
Radioisotopes are used in studying the dispersion of adult white pine weevils. Weevils are tagged with radioactive scandium and released. Their movement from the point of release is traced by means of a scintillation counter.



tors such as parasites and predators, on the insect and its survival; the resistance of different tree species and strains of white pine to weevil attack; the effect of different degrees of release of white pine in mixed white pine-hardwood stands on weevil attack; and, through the use of radioisotopes, the dispersion of white pine weevil adults.

Studies of the Matsucoccus scale on red pine are being conducted to determine if it will attack any other conifer species. It is suspected of having been introduced into this country on some exotic tree species. Studies are also under way to determine whether low temperatures exert a controlling effect that might limit its potential range in this country. The role of predators as natural control factors is being investigated.

Studies of the balsam woolly aphid and beech scale are being conducted to determine the relation of population increase to such factors as tree size, density of stand, forest composition, condition, and so on. This information is needed as a basis for determining the possibility of control through forest management.

Studies have been initiated to determine the species of insects that attack the cones and kill the seeds of white pine. Once the insect species have been identified, their life histories and habits will be investigated to provide information basic to control measures.

Studies in cooperation with Pennsylvania will be conducted to determine the possible role of the pit-making oak scale in killing chestnut oak.

Biological Control

Work in this field will be expanded in 1956. It is planned to initiate what might be called a "biological-control survey." This would be tied in with the forest-insect-survey program. Through collections and special observations, a determination would be made of the current status of biological-control factors (parasites, predators, and disease) for some of the pests for which special surveys are conducted.

Several specific problems in the field of biological control will be investigated. Work will be continued in cooperation with the Maine Forest Service in the rearing of Phytodietus, a western parasite of the spruce budworm, to provide colonies of this parasite for release in northern Maine.

Releasing predators of the balsam woolly aphid. The predator *(Leucopis obscura)* is of European origin. It is being colonized in the Northeast to combat the balsam woolly aphid, a serious introduced pest. This heavily infested tree is in a stand in Vermont.

The balsam woolly aphid predator, Leucopis obscura, will be collected in eastern Maine and reared in our laboratory. Colonies of the predator will be released in aphid infestations in New Hampshire, Vermont, and New York; and some may be sent to Oregon where heavy infestations of aphid occur at present.

Studies will be conducted to determine if the fungus Aspergillus is parasitic on the white pine weevil.

Rearings and dissections of the European pine shoot moth and Nantucket pine tip moth collected from several localities will be made to determine the parasite species present. When the distribution of the different parasite

species is known, we may decide to rear some of them for colonization in areas where they do not occur.

Special emphasis will be given to investigations of virus diseases of sawflies and their possible dissemination by ground and aerial equipment.

Studies will be begun to determine the possibility of controlling the white pine weevil or other forest insects through sterilizing the adults by exposure to irradiation.

Chemical Control

It is hoped that a large-scale control test in airplane spraying with DDT for white pine weevil control may be conducted in cooperation with the New York Conservation Department.

Studies will be continued in an attempt to improve the knapsack sprayer-lead arsenate method for controlling the white pine weevil. The knapsack mist blower will be used in some of the tests. Chemical tests for Pales weevil control will be conducted.

Screening tests with new insecticides--particularly systemics, for control of the European pine shoot moth--will be continued. Large-scale tests with aircraft will be made with one or two of the systemic poisons that, with knapsack spraying equipment, gave good control of the shoot moth in 1955.

Initial tests with chemicals applied with a mist blower will be made in an attempt to control insects that infest white pine cones. Investigations of the chemical control of the Matsucoccus scale on red pine will be continued. Studies will be undertaken to develop chemical methods for controlling the old-house borer.

FOREST MANAGEMENT

PERHAPS THE MOST noteworthy development in forest-management research in 1955 was positive action toward starting an integrated program of research in white pine. A stationwide conference to thrash out the scope, content, and priorities of this research was held in New Haven in February 1955. From this conference a definite program for the next 5 years has been developed, together with somewhat tentative projections of the work through the second 5 years --to 1965. This program will cut across divisional lines, encompassing forest-management and genetics research, insects and diseases research, economics studies, and possibly some work in utilization.

Prior to the conference, an intensive review of the literature on white pine had been begun. This has resulted in selection of some 1,500 titles that, with annotations, are to be published as a bibliography of the species. Immediately after the conference, action was started to get certain of the high-priority studies under way, notably genetics studies to ascertain the importance and degree of racial variation in white pine, and to search for possible individuals or strains that carry genetic factors for resistance to the white pine weevil and other pests. During the fall of 1955, seed was obtained from 24 sources for racial or provenance studies. Arrangements have been made for producing nursery stock from these seed lots; and sites for the later field planting of the stock are being selected. Much of this work is being done in cooperation with other experiment stations and other agencies throughout the range of white pine.

Tied in with the white pine program, results of the 1954 tests of aerial spraying on the Massabesic Experimental Forest, to release white pine reproduction from competition, are highly gratifying. The treatments were 1 pound and 3 pounds of 2,4,5-T in $2\frac{1}{2}$ gallons of oil solution per acre, applied by helicopter in July. Though pine seedlings were released fairly well by the lighter treatment, the 3-pound dosage did an appreciably better job of killing back the hardwood sprout and brush growth and the scattered hardwood overstory. Except for the resistant red maple, practically all hardwood tops were killed back. Most of the birch--and almost half of the oak--appeared in 1955 to have been root-killed. The pines suffered only an insignificant amount of injury and are expected to get up past the new hardwood sprouts and scattered surviving residual stems without difficulty.

In 1955, about 80 acres more were sprayed by helicopter, and a smaller area was treated with a tractor-mounter mist blower, applying 3 pounds of 2,4,5-T per acre. A good top kill appears to have been achieved by both methods.

Work in compartment-management studies at seven experimental forests has continued during the past year, in general according to plan. However, on the Massabesic and Pocono Experimental Forests, most of the harvest cutting in 1955 was devoted to salvage of timber blown down in the storms of 1954. Salvage has been finished on the Massabesic, but continues on the Pocono where operators are willing to pick up widely scattered black cherry, even at considerable distances from truck-loading points.

Because of excessive wind damage from several storms of recent years, coupled with an acute deer problem and poor markets for low-grade material, the scope of the compartment studies on the Pocono Experimental Forest has been reduced; and plans are being revised accordingly. Emphasis in the forest-management work at the Kingston Research Center will be shifted more to smaller scale silvicultural studies, and to forest-wildlife relationships.

The farm-woods studies at the various experimental forests also are continuing essentially as planned; and, as the 5-year points are approached or passed, some are yielding significant results. In 4 years of operation on a white pine woodlot on the Massabesic, cutting a little less than the annual growth each year, and cutting mostly the weak, defective, or crowded trees so as to improve the stand, a landowner doing his own work would have realized nearly $18 a day for his time. And he would have improved his woodlot while so doing.

On the Fernow Experimental Forest, two tracts of farm woods after 5 years of operation have not paid so well as the pine lot cited above; but they have paid the equivalent of local wages for improvement cuts of the lowest quality material. With the owner doing the work, one lot would have paid 72 cents per hour of labor, the other $1.13. Meanwhile, the stands have been improved in volume and quality of stocking, so that future returns will be higher.

Along with the compartment and farm-woods studies, various other studies in silviculture, regeneration, genetics, and related fields are under way at the different research centers. Here we shall merely highlight a few of the more significant findings or developments.

At the Adirondack Center the program of studies dealing with use of sodium arsenite for killing trees in stand-

improvement operations, and for debarking pulpwood for harvesting, has caught the interest of several forest-land-owning corporations and the New York Conservation Department. These concerns are trying the research center's techniques on a modest scale; and if the results are good they presumable will adopt them for widespread use on their lands.

A plan for converting the Dilldown watershed in Pennsylvania from scrub oak and brush to a cover of tree species was submitted late in the summer to the Pennsylvania Department of Forests and Waters. Conversion is required as the next major step in a long-term cooperative watershed-management study on the upper Dilldown drainage. The plan, based upon planting and seeding experiments under way at Dilldown since 1948, has been accepted with certain modifications by the State; and site preparation work with a heavy root rake has been started for the first conversion planting next spring.

In southern New Jersey, re-measurement of some oak thinning plots after a lapse of 20 years has shown that, for sapling sprout oak stands on these poor sites, thinning does not significantly increase growth of the ultimate crop trees. Since the thinning was noncommercial, it represented an investment from which no practical benefits were derived. Presumably the results would be similar for oak on similar poor sites in other regions.

Valuable basic studies on the elements of forest site quality, and on classifying forest-land capability, have been done in the northern Appalachians of West Virginia; and the results have been published or accepted for publication in technical journals. Site studies of oaks have shown that site index is strongly correlated with aspect, position on the slope, grade of the slope, and soil depth to bedrock. Methods have been worked out whereby site index can be estimated from information on these factors.

In the spruce-fir type in Maine, conventional methods for determining site index from height and age of trees do not apply because these tolerant species may live for years but grow very little under an overstory canopy. A different method was needed and has been devised, whereby site index can be determined from measurements of tree heights and diameters. Also a basic study on the elements of site quality for red spruce, somewhat analagous to the work on oaks in West Virginia, is nearing completion.

Methods of cutting in old-growth northern hardwoods have been found important to the composition of ensuing reproduction. The proportion of intolerant species that be-

come established is definitely correlated with the degree to which the site has been exposed by the cutting. Simply by proper choice of harvest cutting method, the skillful forest manager thus is given a means by which he can considerably influence and modify the make-up of reproduction.

Further progress was made in 1955 on a study that bids fair to reduce the present inventory job load in the compartment studies by perhaps as much as 50 percent. This would be achieved by substituting plot sampling in part for the 100-percent inventories now being made before and after each cutting on most of the experimental forests. Since inventories constitute the greatest single labor requirement in the compartment studies, anything that will lessen this requirement without sacrificing accuracy will be a real boon. Recommendations on adoption of plot methods are expected to be ready soon for transmittal to the research centers.

The Station has been working with U.S. Forest Service Region 7 Division of Engineering since 1951 in testing and demonstrating chemical methods for control of brush along forest roads and trails, and on telephone right-of-ways and ski slopes on the national forests. This phase of the work has been concluded; and, based on the results obtained, chemical methods for brush control are being put into practice on all the national forests in the region. Substantial savings over previous mowing costs are expected.

Though a number of fast-growing poplar hybrids have been produced and tested to a limited extent during the past 20 or 30 years, there was need for much more extensive testing to determine soil and climatic adaptabilities. Late in 1954 an article was published in the FARM JOURNAL, in which landowners were invited to cooperate in testing these hybrids. As a result, cuttings were distributed to some 3,500 people through the country, and first-season reports on growth and survival are now coming in. The outcome of this rather unusual experiment in mass public cooperation is awaited with much interest.

WATERSHED MANAGEMENT

PROGRESS IN watershed-management research was marked by construction of additional stream-gaging facilities at the Fernow and Hubbard Brook Experimental Forests, program development and reconnaissance surveys at Hubbard Brook, and completion of the pre-treatment calibration period for the Dilldown watershed on the Delaware-Lehigh Experimental Forest.

The past year brought both summer droughts and disastrous floods from hurricane rainfalls. These focused attention all too pointedly on water shortage and excess problems that deserve concentrated study.

Delaware-Lehigh Experimental Forest

With the completion this year of our third report (giving two more years of daily streamflow and climatic data) for the Dilldown watershed, attention was directed to analyzing the 6 years of accumulated records. Results indicate that the record is long enough to permit prediction of annual and seasonal flow at the required level of accuracy. Accordingly, the 5-year job of converting this 1,530-acre scrub oak watershed to conifers will begin next spring.

Completion of the pre-treatment calibration period was marked by a fire that burned over about 300 acres of the watershed. In places the fire was severe enough so we can consider it as a part of the treatment necessary for eradicating the scrub oak prior to planting.

The soil-moisture--soil-strength survey conducted in cooperation with the Infiltration Project of the Southern Forest Experiment Station was completed in June. The large amount of information obtained on physical characteristics of representative soils of this region will be compiled for publication.

Fernow Experimental Forest

Now that the fourth year of streamflow and climatic records on the five experimental watersheds have been collected, statistical analyses will be made to determine the length of the calibration period, or the time required before the watersheds can be subjected to different levels of timber cutting. With construction of two 120° V-notch weirs, two more watersheds were added to this study to permit necessary treatment replication.

Annual road-erosion measurements were continued, and a comparison of precipitation catch in tilted and vertical gages was started.

Logging-road-erosion studies and logging-arch road construction continue to draw and interest visitors. During the growing season, 22 show-me trips were conducted. Some 225 visitors took part. Most have been impressed with the fact that even in steep country it is not only possible but practical to lay out roads with a grade of only 10 percent.

Hubbard Brook Experimental Forest

The Hubbard Brook watershed was officially made an experimental forest on May 17. Much of this first year's work was devoted to exploring the area and developing a program. With cooperation of the Soil Conservation Service, a soil survey of the Forest was made. Ground-water geologists checked on the water-tightness of tributary subwatersheds. A thorough reconnaissance was made to select possible experimental watersheds and stream-gaging sites. One 90° V-notch weir was constructed to gage streamflow from a 40-acre watershed, and precipitation gages were installed at three locations.

Additional tasks included surveys of flood and erosion damage from the August hurricanes; gradual development of a research program through continued consideration of research problems with interested persons; an analysis of frost data collected in 1950-52, and preparation of a report describing the relation of forest type and condition to occurrence and depth of impermeable frost.

Bartlett Experimental Forest

In a beginning effort to determine the effect of northern hardwoods on snow accumulation and rate of snow melting, a short study was conducted at the Bartlett Experimental Forest. Average accumulated interception of snow water in pole stands at time of maximum snowpack was found to be about 10 to 12 percent. To catch the maximum amount of snow and delay its melt as long as possible, narrow openings running in an east-west direction were indicated. The width of the openings will depend on latitude, aspect, slope, and height of the trees--all factors that affect the angle of incidence of the sun's rays and the amount of direct sunlight that reaches the snow surface.

Skid-road revegetation was also given initial study in a test of the effect of five different seed mixtures, with and without fertilizer, on soil stabilization.

Lebanon Experimental Forest

A one-season study of soil moisture was started in April on upland sites in the New Jersey Pine Region to determine the soil-moisture regimen under five different types of vegetation: mature hardwood, mature pine, pine saplings, pine reproduction, and a bare area. Results will be interpreted in terms of opportunity for groundwater recharge.

FOREST DISEASES

THE OVERALL FOREST-DISEASE situation in the region did not change significantly during the year. Endemic and noninfectious diseases were observed in their usual frequency; but not enough time has elapsed to enable us to completely evaluate the influence on forest tree vigor of the unusually high summer temperatures in 1955, which were unprecedented in their magnitude and duration.

Excessive unexplained dying of red, black, and scarlet oaks has been reported for several years in the Allegheny Plateau region of New York and Pennsylvania. This year it was reported throughout Pennsylvania and West Virginia. Research on its cause and the potential threat to oak stands has been started. Sweetgum blight, another disease of unknown cause, continued to cause deterioration in forest stands at much the same rate as in previous years.

Bleeding canker of sugar maple was unusually prevalent in southeastern New Hampshire and southwestern Maine, but previous experience with this disease does not indicate that a serious epidemic is threatened. Root and butt rot caused by Fomes annosus was observed frequently in central and southern New England in plantations of red pine and other conifers, particularly in stands that had been thinned. Research is under way to determine methods of preventing infections with this disease and to define areas or soil types where it may be a serious problem.

Oak wilt surveys were conducted by several states, and state-wide control programs were in operation in the three states where the disease has been found: Pennsylvania, Maryland, and West Virginia. Additional oak wilt infection centers were located within the previously known limits of the disease, but no observations of its spread into wilt-

free areas were reported. Of interest to this region are the damage figures from oak wilt in an eight-county area in Wisconsin where the disease has been present for at least two decades and no control has been attempted. About 2 percent of the total oak area is now infected, and about 0.3 percent of the total oak volume is killed annually. Application of these figures to the oak stands of this region offers ample justification for adequate control.

Some Research Results

The Division conducted research on 29 disease projects during the year and submitted 12 manuscripts for publication. Some results not previously reported are indicated below.

Mortality of old-growth red spruce in Vermont was found to be associated with but not caused by butt and stem rots. Overmaturity and adverse site conditions are considered to be primary causal factors.

A method of classifying the stages of decay in wood by microscopical characteristics was developed, based on a study of the microscopical changes that occur in Sitka spruce wood subjected to decay by seven wood-rotting fungi in pure culture for varying periods of time. The relationship of decay-class rating to toughness was determined.

Additional evidence was obtained of the efficiency of soil covers for reducing the moisture content of wooden subfloor timbers in basementless houses to a safe level. A polyethylene film was added to the other soil-cover materials under test; it has given satisfactory results for 1 year.

Effective control of soil-inhabiting, water-conducting, wood-decay fungi was obtained by treating the infected soil with compounds of arsenic, mercury, and zinc.

An improved technique for diagnosing blister rust mycelium in white pine tissues was published.

A species of Verticillium isolated from a wilting yellow-poplar tree in Connecticut was identified as V. albo-atrum. Inoculation of yellow-poplar saplings confirmed the pathogenicity of the fungus.

Further evidence was obtained of resistance in American chestnuts to the chestnut blight fungus. Scionwood from 28 additional old American chestnut trees that have survived repeated attacks by the fungus in Massachusetts, Connecticut, New York, Maryland, Virginia, and Missouri was

collected and successfully grafted to American and Asiatic chestnut root stocks. The grafted trees will be subjected to nursery and field tests to determine whether or not they are genetically resistant to the disease.

An annotated list of the diseases of North American trees growing in foreign countries has been submitted for publication as a Department of Agriculture Handbook.

FOREST ECONOMICS

IN 1955, as in previous years, the forest survey was the chief activity of the Division of Forest Economics. Most of the Division's other investigations were conducted in the field of forest-products marketing.

Forest Survey

The forest survey in the Northeast, part of the nation-wide forest survey, is gradually nearing completion of its initial phase. During 1955 another 5 percent of the region was inventoried, bringing the total to 81 percent of the total forest land area. The initial inventory is now completed in all the Northeastern States except Maine, New Jersey, and Delaware. About one-fourth of Maine and New Jersey have been covered, but no inventory work has been started in Delaware. Including the 3,000,000 acres surveyed by field crews in Maine and New Jersey in 1955, nearly 62,000,000 acres of forest land have now been inventoried.

The forest survey has always been a cooperative undertaking. For example, the Maine survey was planned with the help of the Forest Commissioner and the Maine Advisory Council. The State supplied new aerial photography and provided quarters for the survey field crews. Aerial photographs were also provided by the International Paper Company, Scott Paper Company, Great Northern Paper Company, and S. D. Warren Company during the year. These and other companies and agencies have already promised to make available enough aerial photography to carry the forest-survey inventory forward for 1956 and perhaps longer. These aerial photographs provide coverage for two-thirds of the State; new photographs will be needed for the remaining one-third. Similar excellent cooperation in forest inventory has been received from the State of New Jersey. Aerial photographs of

Delaware will be made available by the State Forester when field work begins next year.

Although estimates of net annual growth and timber mortality are obtained as a part of the forest inventory, estimates of timber-products output and timber cut require a separate canvass of producers and separate studies of tree utilization in the woods. During 1955 a canvass of producers, for timber-products-output estimates, was begun in Delaware and New Jersey. Tree-utilization studies were also started in both of these states.

As a result of the utilization studies conducted in many parts of the Northeast over a period of years, the Station has accumulated a sizable number of tree measurements, which have become increasingly useful to forest managers. Analyses of these data during the year provided new estimates of the upper-stem volume and limb volume of northeastern hardwoods. The relationships of stump diameter to diameter breast high were determined for beech, yellow birch, sugar maple, northern red oak, and yellow-poplar.

Results of the forest survey are usually reported in one or more ways. For some states a statistical report is released first, and this is followed later by an analytical report. For other states a combination statistical-analytical report is issued. During 1955, statistical reports were prepared for the State of New York and for seven of the eight geographical sections of Pennsylvania.

Resource Economics

The Station's work in resource economics involved analyses of the timber resources in states where the forest survey is completed, and forest-products-marketing research.

Analysis of the timber resources of New York was made in cooperation with the New York State College of Forestry and the State Conservation Department's Division of Lands and Forests. This report is now being reviewed prior to publication. Statistical-analytical reports for Massachusetts, Connecticut, and Rhode Island are in draft form.

Three different marketing-research projects were carried on during the year. The first was concerned with development of specifications for farm dimension lumber made from local timber. As a part of this study a survey was made of the bending strength of such lumber in the yards of local sawmills. The purpose of this study was to investigate a large potential market for rather low-grade timber and at the same time provide farm builders with a new and relative-

ly cheap source of lumber. The data obtained from the survey are now being analyzed by the U. S. Forest Products Laboratory in Madison, Wisconsin.

The second project was a regional investigation carried on in cooperation with the agricultural experiment stations in eight states. As a part of the first phase of this project the Station helped prepare a regional report on forest-products-marketing practices, pricing, and the factors that affect farm-forest marketing in particular. As a part of the second phase, the Station is participating in a study of the adequacy of marketing facilities in relation to the forest resource. The Station has helped to obtain market data from handlers of forest products in 3 of the 11 states covered by the study. The field work for this second phase has now been completed and analysis has been started.

The third project was aimed at development of white pine log grades. In cooperation with the New York State College of Forestry and the Northeastern Lumber Manufacturers Association, some 400 white pine logs from 100 selected trees have been diagrammed and their green and dry lumber yield has been graded.

FOREST UTILIZATION

THE STATION'S UTILIZATION research program in 1955, as in previous years, was guided by the concepts that are inherent in the terms integrated utilization, full utilization, and efficient utilization. When all or most of the individual operations that make up the region's utilization system can be characterized by all these terms, the system will have reached its maximum usefulness, and intensive forest management with its attendant benefits will be generally practicable. Then a forest owner will be able to cut and sell at a fair price for its highest use any tree that the dictates of good forest management indicate he should cut.

During 1955, special attention was given to problems of integration. Progress toward this goal has been substantial. As is true in other industries, many processors are doing additional jobs, or are adding new lines of products. In recent years sawmills accounting for one-sixth of the region's lumber output have gone into the manufacture of such things as flooring, dimension stock, boxes, and pallets.

Diversification is found at many operating levels. A forester in Connecticut makes improvement cuttings on his own and other woodlands. He operates a sawmill for lumber and a bolter mill for blocking; he sells his fine residues for cattle bedding; he operates two charcoal kilns on heavy residues and woods material too poor for sawing. On the other end of the scale is a large corporation in West Virginia: this firm cuts any tree that should be cut and brings it full length to the mill by rail. There veneer logs are segregated and sold; sawlogs are made into lumber and small dimension stock and flooring; fine residues are efficiently burned for plant fuel, and heavy ones are made into metallurgical chips. A large pulp and paper mill in New Hampshire sorts high-grade sawlogs from the yield of its forest operations: the poor logs and poor lumber from the good logs are raw material for its pulp mill. A turning plant in Maine uses the portion of its raw material that is suitable for dowels and sells the rest for pulpwood and chicken litter. In the mining areas of Pennsylvania it is common practice for sawmills to cut the poorest logs into mine products and the better logs into more valuable items to be sold elsewhere. Many loggers sort their cut and sell logs into a variety of markets.

Full utilization and integrated utilization often go together. One firm in Maine that manufactures wooden heels achieves complete utilization by using wood residues for wood flour and bark residues for heat. Recently this firm installed two log debarkers to service five sawmills. The complete set-up, although made up of independent units, now achieves complete log utilization by producing wooden heels, lumber, wood flour, pulp chips, and heat. In New Hampshire one particle-board plant uses the slabs and edgings from a number of sawmills as raw material. Another uses planing-mill shavings. Processors in West Virginia, Pennsylvania, and New York take slab wood from many mills for metallurgical chips or charcoal. Both sawdust and shavings are in short supply for agricultural use in many sections.

These are but a few examples that indicate an ever-lessening waste factor in this region; or conversely, more complete utilization. They also show a form of regional integration by which the offal of one independent enterprise supplies the raw material for another.

Full utilization and integrated operations do not necessarily mean efficient operations. Yet there is no question but that there has been a general improvement in efficiency. The progress in the woods has been striking. Power saws, skidders, loaders, and specially designed trucks are the rule rather than the exception--all over the region.

Our sawmills are settling down: over three-quarters of them are now permanently located. Benefits from this settling-down are opportunities for fuller utilization and diversification, as well as increased efficiency. Recently much modern equipment has been acquired by this segment of the industry, including push-button carriages, gang saws, dry kilns, lumber-handling machines, and secondary manufacturing machinery. There are exceptionally fine planing mills; and the concentration-yard system is expanding. The turning industry is outstanding in its modernization program. Our pulp-and-paper industry is going forward; it is installing additional pulp-and-paper-making equipment and is turning more and more to high-yield processes that use hardwood. This will not only increase efficiency in use of wood, but will also strengthen the region's forestry program.

These significant improvements have not been the effect of any one cause. The utilization system in this region is an almost indescribable mixture of elements: primary, secondary; large, small; new, old; individual, corporate; land-owning, timber-buying; rural, urban--to list but a few. Progress has been achieved in an evolutionary manner for the most part, and many agencies have taken part in stimulating and directing the effort. Among them are the industrial units themselves, manufacturers, distributors, users, associations, private laboratories, consultants, schools, and other public institutions such as this Station. The effort has run the gamut from fundamental research to product promotion. It is and must be continuous and varied. The Northeastern Forest Experiment Station, through its utilization program, has contributed effectively to the movement.

In 1955, for example, the Station played a major part in a series of clinics, work shops, discussion groups, formal meetings, schools, and demonstrations at which technical and economic problems, new processes, and research results were discussed by more than 1,200 persons. These groups were sponsored by colleges, associations, societies, committees, and the Station itself. Subjects included all phases of wood utilization: primary fields such as timber quality, logging, sawmilling, veneer-making, and pulp manufacture; and secondary fields such as laminations, wood chemistry, furniture finishes, seasoning, waste utilization, and wood preservation--to list but a few.

In addition to participation in these activities, Station activities included a cooperative study of white pine quality, investigations into the problem of veneer-grading, last-block manufacture, integrated utilization, residue use, charcoal manufacture, and the strength charac-

teristics of ungraded native construction lumber. Four additional papers in a cooperative project on beech utilization were published (bringing the total up to 14). The Station guided to completion a study leading to a new manual for sawmill operators. Participants in this project were the Forest Products Research Society, the American Society of Mechanical Engineers, and the American Standards Association. In addition, studies were made of timber utility in Massachusetts, of the make-up of the sawmill industry, and of regional log-scaling practices. About 300 requests for information were filled; these ranged from such simple ones as student inquiries on logging methods to complex ones dealing with corporate expansion.

1955 PUBLICATIONS

by staff members and cooperators of the Northeastern Forest Experiment Station, Forest Service, U. S. Dept. Agriculture

Anonymous.
1955. NORTHEASTERN FOREST RESEARCH ADVISORY COUNCIL CONSIDERS RESEARCH SCHOLARSHIP PROGRAM. Northeast. Logger 4 (3): 16-17, illus.

Report on annual meeting of this Advisory Council, which appointed committee to study possibilities of raising scholarship fund to help research men of the Northeastern Forest Experiment Station finance advanced study.

*Baker, Gregory, and McMillen, John M.
1955. SEASONING BEECH LUMBER.
Northeast. Forest Expt. Sta. and Northeast. Tech. Com. Util. Beech, Beech Util. Ser.: 11. 22 pp., illus.

Beech lumber is difficult to dry without serious loss. Seasoning characteristics of the wood are described; and methods are recommended for air-drying, kiln-drying, and chemical seasoning that should give satisfactory results. Kiln schedules given.

*Copies or reprints available from the Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pa.

*Banks, Wayne G.
1955. SIZE OF TREES CUT IN THE NORTHEAST FOR SAWLOGS AND PULPWOOD. Northeast. Forest Expt. Sta., Forest Res. Note 47. 5 pp.

Information about the size class of trees that are cut for various products was gathered in wood-utilization studies made in 1947-54 in connection with forest surveys. Data are presented in tables for New England and Middle Atlantic States.

*---------- and Hampf, Frederick E.
1955. ESTIMATING UPPER-STEM AND LIMB-WOOD VOLUME IN NORTHEASTERN HARDWOODS. Northeast. Forest Expt. Sta., Forest Res. Note 50. 2 pp.

The cubic-foot volume in limbs and tops of hardwood trees is hard to measure: so measurements made in woods-utilization studies were used to develop factors for relating these volumes to board-foot volume of hardwood sawtimber trees of various height classes.

Barr, Carl R.
1955. SAFETY PROGRAM ON THE FERNOW EXPERIMENTAL FOREST. Northeast. Logger 3 (12): 16-17, 33, illus.

A logging boss tells how a safety program pays off. Safety meetings are held for the woods crew once a week to discuss hazards and safe ways of doing hazardous jobs. The crew maintain a safety record on their tool house--and are proud of it.

Barraclough, Solon L., and Gould, Ernest M., Jr.
1955. ECONOMIC ANALYSIS OF FARM FOREST OPERATING UNITS. Harvard Forest Bul. 26. 145 pp. Petersham, Mass.

Report on an economic study of farm woodlands in rural New England. Based on planning economic operations on one woodland-dairy farm and case studies of eight other farms. A need is seen for better input-output data.

*Bean, James L., and Godwin, Paul A.
1955. DESCRIPTION AND BIONOMICS OF A NEW RED PINE SCALE, MATSUCOCCUS RESINOSAE. Forest Sci. 1: 164-176, illus.

This scale, first reported in 1946, has killed red pine over areas of 60 square miles in Connecticut and 40 square miles on Long Island. No method of control, either by chemicals or predators, has been found. Technical description, distribution, host relationship, effect on host, economic importance, and habits and seasonal history.

Brown, Raymond C.
1955. FOREST INSECTS IN THE NORTHEAST. Northeast. Logger 4 (6): 26-27, 58-59, 72, illus.

Describes the major forest insects found in the

Northeast, the damage they do, and how man is partly responsible for many of the forest-insect problems in the region today. Some control methods are outlined. Spruce budworm, white pine weevil, forest tent caterpillar, gypsy moth, balsam woolly aphid, beech scale, and Matsucoccus scale of red pine.

*Church, Thomas W., Jr.
1955. STOCKING AND YIELD OF VIRGINIA PINE STANDS IN PRINCE GEORGES COUNTY, MARYLAND. Northeast. Forest Expt. Sta., Forest Res. Note 44. 4 pp., illus.

Presents stocking and yield data from a small study made on the Beltsville Experimental Forest in Maryland. The stands sampled ranged in age from 15 to 70 years.

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1955. OBSERVATIONS FOLLOWING WILDFIRE IN A YOUNG STAND OF VIRGINIA PINE AND HARDWOODS. Northeast. Forest Expt. Sta., Forest Res. Note 49. 2 pp.

Observations on effects of a small wildfire in a 30-year-old pine-hardwood stand near Beltsville, Md., indicate that here the fire improved conditions for better germination and survival of Virginia pine seedlings.

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1955. WEEDING--AN EFFECTIVE TREATMENT FOR STIMULATING GROWTH OF NORTHERN HARDWOODS. Jour. Forestry 53: 717-719, illus.

To produce valuable tree crops from young northern hardwood stands, the fast-growing weed species must be controlled. Weeding was found effective in Allegheny Plateau forests for growing crop trees of black cherry, sugar maple, and other desirable species.

Connola, D. P., McIntyre, T., and Yops, C. J.
1955. WHITE PINE WEEVIL CONTROL BY AIRCRAFT SPRAYING. Jour. Forestry 53: 889-891, illus.

Results of experiments made in New York State indicate that airplane spraying (both helicopter and fixed-wing plane) with DDT can be used successfully to control white pine weevil. Aerial spraying is the only practical method of treatment for large acreages.

*Curry, John R., and Rushmore, F. M.
1955. EXPERIMENTS IN KILLING NORTHERN HARDWOODS WITH SODIUM ARSENITE AND AMMONIUM SULFAMATE. Jour. Forestry 53: 575-580.

Adirondack forests contain large numbers of cull hardwoods that should be poisoned or girdled. This article reports on a comprehensive study of the quantities of sodium arsenite and ammate required to kill large beech, birch, and

maple trees at two different seasons of the year. The chemicals were applied in solution through holes bored in the trees.

*Curtis, Robert O.
1955. USE OF GRADED NURSERY STOCK FOR RED PINE PLANTATIONS. Jour. Forestry 53: 171-173, illus.

In two studies of plantations on the Allegheny Plateau in Pennsylvania, large seedlings were found to have an advantage in growth rate over smaller planting stock; and they still held this advantage after 12 years. Different planting methods tried gave only slight differences in survival, growth, and frost heaving.

Diller, Jesse D.
1955. SURVIVALS AND HEIGHTS OF VARIOUS GRADES OF RED SPRUCE TRANSPLANT STOCK. Jour. Forestry 53: 843, illus.

Five grades of nursery stock were outplanted in the Monongahela National Forest; and records of survival and height growth over the period 1943-54 show the importance of healthy planting stock to subsequent survival and growth.

Dunford, E. G., and Weitzman, Sidney.
1955. MANAGING FORESTS TO CONTROL SOIL EROSION. In Water (U. S. Dept. Agr. Yrbook 1955): 235-242.

Outlines principles of integrating forest and watershed management to control erosion from forest lands. Recommends measures of fire prevention, grazing control, logging, and construction of logging roads that are useful in erosion control.

*Fenton, Richard H.
1955. WINDTHROW A HAZARD IN VIRGINIA PINE STRIP CUTTINGS. Northeast. Forest Expt. Sta., Forest Res. Note 53. 3 pp.

Study of damage from a hurricane and smaller storms shows that the possibility of wind damage should be considered in managing forests that contain large proportions of Virginia pine.

Gilbert, Adrian M.
1955. THE NEW HAMPSHIRE HOME OF HARDWOOD RESEARCH. Soc. Protect. N.H. Forests, Forest Notes 48: 12-15, illus.

Defines briefly the forest situation in New Hampshire and tells how the research work carried on by the U.S. Forest Service at the Bartlett Experimental Forest seeks solutions to the problems of managing hardwood forests in New Hampshire.

Gilbert, Adrian M.
1955. WHAT IS THIS THING CALLED GROWTH? South. Lumberman 190 (2371): 29.

Suggests a new approach to use of growth data. The basic elements related to growth (accretion, mortality, ingrowth, net growth, production, and volume increase) are defined; and an example shows how they are used to figure how much timber can be cut during a growth period.

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---------- Wilson, Robert W., Jr., and Hutnik, R.
1955. GROWTH BEHAVIOR OF NORTHERN HARDWOODS AFTER A PARTIAL CUTTING. Jour. Forestry 53: 488-492, illus.

The authors trace the development of a northern hardwood stand for 15 years after an experimental partial cutting. Their analysis of growth behavior leads to some practical recommendations for managing northern hardwood stands.

*
Hamilton, Lawrence S.
1955. SILVICULTURAL CHARACTERISTICS OF AMERICAN BEECH. Northeast. Forest Expt. Sta. and Northeast. Tech. Com. Util. Beech, Beech Util. Ser.: 13. 39 pp., illus.

Describes site requirements and occurrence of beech, and species features such as light requirements, morphological features, reproduction, susceptibility to injury, defect, and growth and yield. Some suggestions as to cutting practices and management policy.

*
Hampf, Frederick E.
1955. RELATIONSHIP OF STUMP DIAMETER TO D.B.H. FOR SUGAR MAPLE IN THE NORTHEAST. Northeast. Forest Expt. Sta., Forest Res. Note 42. 3 pp., illus.

Stump diameter-d.b.h. relationships for sugar maple were worked out from data gathered on logging operations. Presented in graph form, these relationships are expected to give reliable d.b.h. estimates for sugar maple anywhere in the Northeast.

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1955. RELATIONSHIP OF STUMP DIAMETER TO D.B.H. FOR AMERICAN BEECH IN THE NORTHEAST. NORTHEAST. FOREST Expt. Sta., Forest Res. Note 43. 3 pp., illus.

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1955. RELATIONSHIP OF STUMP DIAMETER TO D.B.H. FOR YELLOW BIRCH IN THE NORTHEAST. Northeast. Forest Expt. Sta., Forest Res. Note 45. 3 pp., illus.

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1955. RELATIONSHIP OF STUMP DIAMETER TO D.B.H. FOR NORTHERN RED OAK IN THE NORTHEAST. Northeast. Forest Expt. Sta., Forest Res. Note 46. 3 pp., illus.

*Hampf, Frederick E.
1955. RELATIONSHIP OF STUMP DIAMETER TO D.B.H. FOR YELLOW-POPLAR IN THE NORTHEAST. Northeast. Forest Expt. Sta. Forest Res. Note 55. 3 pp.

Heller, R. C., Coyne, J. F., and Bean, J. L.
1955. AIRPLANES INCREASE EFFECTIVENESS OF SOUTHERN PINE BEETLE SURVEYS. Jour. Forestry 53: 483-487, illus.

Conventional ground survey methods are too slow and expensive for use in surveying aggressive epidemics of the southern pine beetle. An aerial survey method, using a high-wing monoplane and two observers, was used to locate and map infected areas.

Hough, A. F.
1955. THE LONG-LASTING EFFECTS OF FOREST FIRES ON THE ALLEGHENY PLATEAU. Pa. Forests 45 (2): 36, illus.

Traces the history of the Loleta burn in northwestern Pennsylvania from 1926 to 1955. Pictures taken from the same spot in 1929, 1944, and 1949 show how long Nature takes to reclothe the burned area with tree growth. The severe microclimate, dense ground cover of bracken fern and grass, browsing by deer and rabbits, and distance from seed sources play a part in the slow recovery of the area.

*Hutnik, Russell J.
1955. BARTLETT EXPERIMENTAL FOREST.
Northeast. Forest Expt. Sta. 32 pp., illus.

An illustrated booklet describing the Bartlett Experimental Forest near Bartlett, New Hampshire, and the research program being carried on there. The 2,600-acre forest is fairly typical of the northern hardwood forests of New England.

Lassen, Leon, Lull, Howard W., and Frank, Bernard.
1955. (Discussion of DOES TRANSPIRATION DECREASE AS THE SOIL MOISTURE DECREASES? by F. J. Veihmeyer and A. H. Hendrickson). Amer. Geophys. Union Trans. 36: 436-438, illus.

Disputes the Veihmeyer-Hendrickson view, adding that a Forest Service field study now under way should do much to clarify the question of how much transpiration decreases as soil moisture decreases.

Lull, H. W.
1955. FOREST SERVICE INITIATES WATERSHED RESEARCH PROGRAM IN NEW HAMPSHIRE. Jour. Soil and Water Conserv. 10: 150.

Describes briefly the watershed-management project authorized in New Hampshire, and outlines work planned on the 7,500-acre Hubbard Brook watershed in the White Mountains.

Lull, Howard W.
1955. WATER SUPPLIES AND OUR FORESTS.
Pa. Forests 45 (3): 58-60.
Sums up the condition of our national water resource, present and future demands for water, and the need for watershed-management research to find ways of assuring adequate future supplies of water.

---------- and Reinhart, Kenneth G.
1955. SOIL-MOISTURE MEASUREMENT.
South. Forest Expt. Sta. Occas. Paper 140. 56 pp., illus.
Because of the importance of soil-moisture records (in agriculture, forestry, and engineering) and the difficulty in getting them, much time and energy have been spent in developing new ways of measuring moisture. This paper reviews most of these methods, describes and compares the most commonly used instruments, and discusses soil-moisture expression, variation, and sampling.

*McConkey, Thomas W.
1955. RETURNS FROM A WHITE PINE WOODLOT.
Northeast. Forest Expt. Sta., Forest Res. Note 41. 3 pp.
An example of how good forest management can be profitable to the owner. Based on four annual cuttings of a 50-acre experimental woodlot in southwestern Maine.

1955. RETURNS FROM A WHITE PINE WOODLOT.
Soc. Protect. N.H. Forests, Forest Notes 46: 32-33. (See above.)

McGuire, John R.
1955. NORTHEASTERN REGIONAL MARKETING PROJECT NEM-6: MARKETING FOREST PRODUCTS. New England Res. Council on Marketing and Food Supply Proc. 1954: 45-47. (Boston.)
Describes procedures used in gathering information about the marketing of forest products for a project under the Research and Marketing Act.

1955. HARDWOOD TIMBER RESOURCES IN THE NORTHEAST AND THEIR AVAILABILITY FOR PULPWOOD. Northeast. Wood Util. Council Bul. 43: 7-12, illus.
New England and New York now have more hardwood timber suitable for pulping than at any time in the last 100 years--a buyer's market. The forest survey shows about 250 million cords of hardwood timber in the Northeast. The cut

of hardwoods is about 3 million cords a year, of which about a fifth goes into pulpwood. The outlook: the supply will increase at least as fast as the demand.

*McQuilkin, W. E.

1955. USE AMMATE IN NOTCHES FOR DEADENING TREES ONLY DURING THE GROWING SEASON. Northeast. Forest Expt. Sta., Forest Res. Note 52. 2 pp.

Results of an experiment on the Pocono Experimental Forest in Pennsylvania bear out earlier observations that, in the North, the ammate notch treatment is more effective when done during the growing season than during the dormant season.

1955. USE AMMATE FOR DEADENING TREES ONLY DURING GROWING SEASON. South. Lumberman 191 (2388): 70.

(See above.)

Marquis, Ralph W.

1955. TAXATION.

Forest Farmers Assoc., Forest Farmer Manual 3d Ed.: 175-176.

A look ahead at trends in taxation and how they may affect the forest farmer. In general, taxes can be expected to rise as taxing units find they need more money to provide essential services. Reviews trends in forest yield taxes, severance taxes, and the flat annual tax used in Wisconsin, which promises to give the small owner a break.

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1955. THE NORTHEAST TIMBER RESERVOIR.

Northeast. Logger 3 (11): 18-19, 50-51, illus.

Describes the timber resource in terms of a reservoir. It holds about 35 billion cubic feet of growing stock; 1/3 softwoods, 2/3 hardwoods. It is fed from some 40 million acres of commercial forest land, most of it privately owned. Despite hard use for 300 years, the reservoir is slowly filling up. But the softwood reservoir is being used up; the surplus is in hardwoods.

1955. RESEARCH WORK OF THE FOREST SERVICE.

Sylvan 1955: 11-12. (Pa. State Univ. Forestry School.)

Outlines the research organization of the U.S. Forest Service and describes, as an example, the research activities of the Northeastern Forest Experiment Station.

Marquis, Ralph W.
1955. THE ADVANCE OF FOREST RESEARCH.
Northeast. Logger 4 (4): 12-13, 42, illus.

In the last 50 years forest research has grown and broadened. It now is concerned with far more than mere silviculture--economics, watershed management, diseases and insects, genetics, and so on. The trend toward decentralization is described, and the healthy growth of cooperation. Though applied results have caught most of the public attention, advances have also been made in basic knowledge.

*McLintock, Thomas F.
1955. HOW DAMAGE TO BALSAM FIR DEVELOPS AFTER A SPRUCE BUDWORM EPIDEMIC. Northeast. Forest Expt. Sta., Sta. Paper 75. 18 pp.

A study of budworm damage in southwestern Quebec was made to get information that might be needed in salvage operations if a budworm threat in Maine becomes epidemic. Reports findings on mortality, survival, growth loss, lag between defoliation and mortality, and time for salvage.

*McNamara, E. F., and Reigner, Irvin C.
1955. ROOT COMPETITION SLOWS GROWTH OF PLANTINGS ON UNPREPARED SITES IN SCRUB OAK. Northeast. Forest Expt. Sta., Forest Res. Note 54. 3 pp.

Height growth of red, jack, and pitch pine planted in scrub oak land in Pennsylvania indicates that root competition exerts an important influence on growth. Extensive interplantings without reduction in root competition cannot be recommended.

Moore, E. B., Smith, G. E., and Little, S.
1955. WILDFIRE DAMAGE REDUCED ON PRESCRIBE-BURNED AREAS IN NEW JERSEY. Jour. Forestry 53: 339-341, illus.

Besides its main use as a silvicultural practice for favoring pine over oak, prescribed burning has value for reducing damage from wildfires. Some striking examples show how less damage is done by wildfires on prescribe-burned areas. And in some cases wildfires that could not be held on other lines were stopped when they reached prescribe-burned areas.

*Northeastern Forest Experiment Station.
1955. ANNUAL REPORT 1954.
Northeast. Forest Expt. Sta. 85 pp.

General survey of trends and events in forestry in the Northeast, and report on research work carried out in forest management, watershed management, genetics, insects, diseases, economics, and utilization. Publications listed.

*Northeastern Forest Experiment Station.

1955. THE TIMBER RESOURCE IN MARYLAND.
Northeast. Forest Expt. Sta. 41 pp., illus.

An analysis of the forest-survey findings in Maryland. Though Maryland consumes much more wood than it produces, an opportunity is seen for using the timber resource to increase forest income and employment, through more intensive management of the forest land and growing stock. The immediate challenge is to find ways of utilizing the present surplus of hardwood timber.

*

1955. FOREST STATISTICS FOR NEW YORK.
Northeast. Forest Expt. Sta. 63 pp., illus.

Statistical summary from findings of the forest survey of New York State: forest area, timber volume, timber growth, timber quality, and timber cut. Brief discussion of ownership, forest types, and condition of the forests.

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1955. FOREST STATISTICS FOR THE ANTHRACITE SECTION OF PENNSYLVANIA. Northeast. Forest Expt. Sta., Forest Statis. Ser.: Pa. 1. 16 pp.

Forest-survey findings for the east-central part of Pennsylvania that includes Luzerne, Carbon, Schuylkill, Montour, Northumberland, and Columbia Counties: forest area, ownership, forest types, and timber volume. Tabular data and brief explanation.

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1955. FOREST STATISTICS FOR THE NORTHWESTERN SECTION OF PENNSYLVANIA. Northeast. Forest Expt. Sta., Forest Statis. Ser.: Pa. No. 2. 16 pp.

Forest-survey findings for Erie, Crawford, Mercer, Lawrence, Venango, and Butler Counties: forest area, ownership, forest types, and timber volume. Tabular data and brief explanation.

*

1955. FOREST STATISTICS FOR THE SOUTHEASTERN SECTION OF PENNSYLVANIA. Northeast. Forest Expt. Sta , Forest Statis. Ser.: Pa. 3. 16 pp.

Forest-survey findings for the southeastern counties of Pennsylvania (Northampton, Bucks, Lehigh, Berks, Montgomery, Philadelphia, Delaware, Chester, Dauphin, Lebanon, Lancaster, York, Cumberland, and Adams): forest area, ownership, forest types, and timber volume. Tabular data and brief explanation.

*Potts, S. F.

1955. A DUAL-NOZZLE SYSTEM FOR MIST BLOWERS. Northeast. Forest Expt. Sta., Forest Res. Note 48. 2 pp., illus.

Describes a new type of dual-nozzle system for mist blowers used in spraying trees to control insects and diseases. A ring of four fine-spray jets make fine droplets that hit the lower part of the tree. A coarse-spray nozzle makes larger droplets that reach the crown of a tall tree.

1955. A DUAL-NOZZLE SYSTEM FOR MIST BLOWERS. Trees 15 (6): 21, illus. (See above.)

1955. NEW KNAPSACK MIST BLOWER. Trees 15 (6): 7, 17, illus.

Describes a new portable mist blower that can be carried on the back into places where skid or wheelbarrow blowers cannot go. The new blower can spray the tops of 30-foot trees and can be used to drift spray for considerable distances.

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1955. EQUIPMENT AND METHODS FOR TREE SPRAYING. Conn. Arborist 9 (1): 2-9, illus.

A progress report on new developments in tree spraying for pest control. Discusses mist blowers and training of operators, use of helicopters, and spray mixtures and concentrations. A dual-nozzle spray for tall trees and a new lightweight mist blower are among the new developments.

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1955. USE OF SPRAYS TO CONTROL THE PALES WEEVIL (HYLOBIUS PALES). Northeast. Forest Expt. Sta., Forest Res. Note 51. 2 pp.

An effective method of spraying has been developed to protect white pine seedlings from Pales weevil in areas that have been recently burned or cut over. Tells when to spray, how to spray, equipment to use, and formulas and how to mix them.

*Sartz, Richard S.

1955. SKIDROAD EROSION. Northeast. Logger 4 (1): 10-11, 51, illus.

Modern logging methods and machines such as the bulldozer that bare the mineral soil have brought an erosion problem to the White Mountains of New Hampshire. Describes how erosion starts and outlines skidroad practices designed to reduce the erosion hazard.

Simmons, Fred C.

1955. LOGGING FARM WOOD CROPS.
U.S. Dept. Agr. Farmers' Bul. 2090. 52 pp., illus.

Tells farmer how he can harvest his timber crops with the equipment he already has or can easily get. Discusses hand tools, farm tractors, and specialized logging equipment and their proper use in laying out the logging job, marking and marketing, felling, limbing, bucking, skidding, loading, and hauling.

1955. HARDWOOD PULPWOOD PROCUREMENT IN THE NORTHEAST.
Northeast. Wood Util. Council Bul. 43: 13-16.

Wood procurement is no obstacle to greatly increased use of hardwood for pulp. One can get almost any reasonable quantity of rough hardwood pulpwood delivered to a mill for about $15 a cord, including a stumpage cost of about 50 cents. Mechanization, methods of purchase, and integrated logging operations are discussed.

1955. NORWAY, ME., CONCERN USES SAWMILL "WASTE".
Northeast. Logger 3 (9): 19.

Describes a sawmill's experience with a chain-flail type of debarking machine. The mill has found that the bark-free slabs, edgings, and sawdust can be used to make high-grade wood flour. The mill also plans to market selected chips at nearby pulpmills.

1955. ADAPTABILITY OF SASH GANGSAW MILLS TO NORTHEASTERN CONDITIONS. Northeast. Forest Expt. Sta., Sta. Paper 78. 7 pp., illus.

The European type of round-log sash gangsaw mill offers attractive possibilities for use in the Northeast, especially for cutting low-grade softwood logs. Outlines capabilities of sash gangsaw, and methods for efficient use.

1955. A LOOK AHEAD IN NORTHEASTERN SAWMILLING.
Forest Prod. Res. Soc. Northeast. Sect. Preprint: 1-5.

The portable sawmill is passing out in the Northeast: the trend is toward permanent mills of medium size (10 to 20 thousand board feet a day). Predicts use of more automatic machinery; more effort to turn waste into byproducts; and more use of specialized mills such as the sash gangsaw and the short-log bolter saw.

*Simmons, Fred C.
1955. NORTHEASTERN SAWMILLING. CURRENT DEVELOPMENTS AND FUTURE TRENDS. South. Lumberman 191 (2393): 127-129, illus.
(See above.)

1955. THE QUESTION CORNER. REPLIES.
Northeast. Logger 3 (7): 8.
Northeast. Logger 3 (10): 20-21, illus.
Northeast. Logger 4 (1): 36.
Northeast. Logger 4 (5): 30.
Replies to loggers' and sawmill operators' questions about equipment and methods.

*--- and Bond, Adna R.
1955. SAWMILL "WASTE" IN MARYLAND.
Northeast. Forest Expt. Sta., Sta. Paper 74. 31 pp., illus.
A survey of sawmill "waste" showed that Maryland sawmills have their problem pretty well in hand, but further improvement is possible through more accurate sawing and finding new uses for some of the leftovers that are not now being used. Data on production and disposal of sawdust, slabs, edgings, and shavings in 1952.

*--- and Bond, Adna R.
1955. SAWMILL "WASTE" IN MARYLAND.
Northeast. Logger 4 (6): 18-21, 62-65, illus.
(See above.)

Sims, I. H.
1955. FOREST MANAGEMENT RESEARCH ACTIVITIES.
Northeast. Logger 4 (4): 16-17, 28-29, illus.
Research in forest management has been under way in the Northeast for more than 50 years. Reviews some of the results now being made use of (control of growing stock, chemical poisoning, prescribed burning, cutting methods, new standards for logging roads and trails); and points toward research needs of the future.

*Trimble, George R., Jr.
1955. WATERSHED RESEARCH BEGINS IN NEW HAMPSHIRE.
Forest Notes 46: 22-25, illus.
Outlines the general water problem in New Hampshire and describes the watershed-management research project begun by the U. S. Forest Service on the 7,500-acre Hubbard Brook Experimental Forest near West Thornton, N. H.

*Waterman, Alma M.

1955. A STAIN TECHNIQUE FOR DIAGNOSING BLISTER RUST IN CANKERS ON WHITE PINE. Forest Sci. 1: 219-221.

Describes a stain technique that is rapid and gives satisfactory differential staining of host and fungus. Formula and procedure are given, and diagnostic characteristics of the blister rust fungus under stain.

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1955. THE RELATION OF VALSA KUNZEI TO CANKERS ON CONIFERS. Phytopathology 45: 686-692, illus.

A serious canker disease of spruce was studied in relation to similar but less serious cankers on other conifers. Morphology of the fungi indicated that the collections represent three varieties of Valsa kunzei, differing slightly in stromal development and formation of a dark zone line delimiting the stromata.

*Waters, W. E.

1955. SEQUENTIAL SAMPLING IN FOREST INSECT SURVEYS. Forest Sci. 1: 68-79, illus.

Sequential analysis, a technique developed in 1943 in war research studies, has proved applicable to forest insect surveys. General formulas for devising sequential plans are given for binomial, negative binomial, Poisson, and normal distributions. An application of this technique for determining spruce budworm larval populations is described.

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1955. FOREST INSECT CONDITIONS IN THE NORTHEAST--1954. Northeast. Forest Expt. Sta., Sta. Paper 76. 22 pp.

Annual review of insect conditions, and plans for survey and control work. Major insects discussed: spruce budworm, white pine weevil, balsam woolly aphid, Matsucoccus scale, forest tent caterpillar, gypsy moth, and beech scale. Tabulations showing conditions and recommended control for major insects and minor insects and shade tree pests.

---------- McIntyre, T., and Crosby, D.

1955. LOSS IN VOLUME OF WHITE PINE IN NEW HAMPSHIRE CAUSED BY THE WHITE PINE WEEVIL. Jour. Forestry 53: 271-274, illus.

A survey of losses due to the white pine weevil was made in 1952, using forest survey plots. The average volume loss was found to be 13 percent in pole-size trees; 40 percent in the sawlog part of sawtimber trees; and 70 percent in the upper parts of sawtimber trees (above the sawlog portion).

*Webber, Laurance E.
1955. BEECH FOR FUEL AND CHARCOAL.
Northeast. Forest Expt. Sta. and Northeast. Tech. Com. Util. Beech, Beech Util. Ser.: 12. 7 pp., illus.

Beech is one of the best fire woods. Heating values and marketing of beech firewood and charcoal are discussed. The small cinder-block kiln for making charcoal is described.

*Weitzman, Sidney, and Trimble, G. R., Jr.
1955. A CAPABILITY CLASSIFICATION FOR FOREST LAND.
Jour. Soil and Water Conserv. 10 (5): 228-232, illus.

Land classification has become standard practice in managing farm lands. The authors propose a system of classification for forest lands, based on four factors: aspect, topographic position, steepness of slope, and soil depth to bedrock.

*---------- and Trimble, G. R., Jr.
1955. INTEGRATING TIMBER AND WATERSHED MANAGEMENT IN MOUNTAIN AREAS. Jour. Soil and Water Conserv. 10: 70-75, illus.

Outlines the importance of the water resource in the Appalachian Mountain area, and the need for integrating timber management and watershed management. Describes some of the research being done on this problem in West Virginia, and recommends logging methods and equipment that will protect the watershed.

Wright, Jonathan W.
1955. SPECIES CROSSABILITY IN SPRUCE IN RELATION TO DISTRIBUTION AND TAXONOMY. Forest Sci. 1: 319-349, illus.

Distributional, genetic, and morphological data are used to formulate hypotheses on the evolution of the genus; and crossability relationships among American species and European and Asiatic species are developed. Crossability barriers seem to have arisen mainly from genic differentiation following geographic isolation. Detailed range maps are given, along with results of reported crossing experiments.

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1955. GENETIC IMPLICATIONS OF LONG-DISTANCE POLLEN TRANSPORT. Ztschr. f. Forstgenetik 4 (4/5): 126-128.

Estimates of long-distance pollen transport rates obtained by extrapolation from short-distance dispersion data are very small for distances of more than 10 miles, indicating that pollen transport over greater distances is relatively ineffective in preventing genetic differentiation.

*Wright, Jonathan W.

1955. DIRECTORY OF FOREST GENETICS RESEARCH AND EDUCATION IN THE UNITED STATES AND CANADA. Soc. Amer. Foresters Com. Forest Tree Improve. 34 pp.

Lists research agencies engaged in forest genetics research and educational institutions that offer courses related to forest genetics. Species studied and types of studies made are indicated.

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1955. A BIBLIOGRAPHY ON FOREST GENETICS AND FOREST TREE IMPROVEMENT, 1954. Northeast. Forest Expt. Sta., Sta. Paper 77. 41 pp.

List of American and foreign publications, prepared from standard forestry, botanical, and abstracting journals, experiment station publications, and correspondence with tree breeders. Prepared at request of Society of American Foresters committee on forest tree improvement.

APPENDIX

THE PAGES THAT FOLLOW contain descriptions of the individual forest insect species that are now causing concern in the Northeast. They are appended here to give the reader more information about these insects than we could conveniently include in the general discussion of forest insects and the research program that is now under way to combat them.

The individual insects have been grouped here according to their feeding habits: defoliators, sucking insects, twig and terminal feeders, bark feeders, cone and seed insects, bark beetles and borers, and insect pests of forest products. An attempt has been made to give, for each insect, a general discription and information about distribution, feeding habits, nature and extent of damage done, life history, and methods of control.

DEFOLIATORS

SPRUCE BUDWORM

Choristoneura fumiferana (Clem.)

The spruce budworm is native to North America. Serious outbreaks have occurred over vast areas in the eastern United States and Canada, in the Lake States, in the Pacific Northwest, and in the Rocky Mountain region. A severe outbreak is now raging in the Canadian Provinces of New Brunswick and Quebec and is threatening the forests of Maine. At present the infestation in Maine is light over most of the State, with a few spots of medium intensity.

In the East, the budworm attacks balsam fir and white and red spruce. Balsam fir is its favorite host. Black spruce is relatively safe. In the West, Douglas-fir and the true firs are the favored hosts.

After they emerge in the spring, budworm caterpillars first mine the old needles; then they bore into the opening buds; and as they grow larger they tie the tips of twigs together and feed on the needles. When the infestation is heavy they devour all of the current foliage and then the old foliage too. Repeated heavy defoliation kills the tree. Even if the trees survive, heavy budworm feeding causes much growth loss.

It is estimated that more than 250 million cords of spruce and fir pulpwood were killed during the 1910-20 outbreak in Quebec, New Brunswick, Maine, and northern Minnesota. About 27 million cords were killed in Maine alone. The present outbreak, which started in Ontario in 1935, may be even worse. By 1947 most of the mature fir and a considerable part of the white spruce had been killed on 20,000 square miles of forested area in Canada. Fortunately no widespread killing has occurred yet in this country during the current outbreak.

CANADA AGR. SCI. SERV. PHOTO

Spruce budworm larva.

The full-grown larva is about 1 inch long and is brownish in color. The eggs are pale green. They are laid in masses on the needles, overlapping like shingles.

In the Northeast the moths are active and lay their eggs in July and early August. The eggs hatch in 8 to 12 days. The young larvae do not feed: they spin small silken hibernacula under bark scales or in some protected place, and they remain there until the following spring. They start feeding in early May and become full grown by late June. The larger larvae, being more exposed, are easier to kill; so this is the time when chemical control is most effective.

Natural control factors, particularly parasites and predators, have been extremely effective in preventing the current budworm infestation from reaching the outbreak stage in the Adirondacks and northern Maine. Airplane spraying with DDT is an effective and practical means of control. Forest management offers promise of control through (1) operating balsam fir stands on a short rotation, and (2) reducing the proportion of balsam fir in mixed stands.

EUROPEAN SPRUCE SAWFLY

Diprion hercyniae (Htg.)

The European spruce sawfly probably arrived in North America some 75 years ago. When first discovered in 1930,

it was seriously defoliating spruce in the Gaspe Peninsula of Quebec. Later it was found well distributed throughout New England, the Adirondacks, and south to Pennsylvania; and through New Brunswick and southern Quebec west to Sault Ste. Marie, Ontario. It is uncommon in Europe, but it seems to be distributed there generally. This sawfly is not causing damage to our spruce forests in the Northeast at present.

The larvae feed only on spruce (Picea spp). They prefer the old growth; in fact they cannot feed successfully upon the current year's growth until it is fully formed. They show some preference for white spruce; and white spruce trees are more easily killed than red or black spruce.

Heavy defoliation of spruce causes loss of growth and eventual death. Between the time the pest was first discovered and the time the outbreak subsided some 10 or 12 years later, about 10 million cords of spruce were killed on the Gaspe Peninsula. Some scattered mortality and considerable loss of growth occurred in adjoining areas in Quebec, New Brunswick, and New England where heavy defoliation was quite common.

The female sawfly is a stout 4-winged fly, black with yellow markings on the abdomen. The full-grown larvae are dark green with five longitudinal white lines. They average about 4/5 inch long. The cocoons are golden to dark brown.

When feeding is completed, the larvae drop to the ground and spin a cocoon in the moss, litter, or humus. They overwinter in this stage. One generation is bred annually in the Gaspe Peninsula. Farther south in central New Brunswick, Vermont, and New Hampshire there are usually two generations. However, the period spent in the cocoon stage varies. In the North an average of only 20 percent of the overwintering cocoons produce adults each spring. The average is about 70 percent emergence in New Brunswick and almost 100 percent in southern New Hampshire. Males are very rare, and parthenogenetic reproduction is the rule. The females are strong fliers. They lay their eggs singly in the needles.

The sawfly outbreak was brought to a sudden and spectacular close between 1938 and 1942 by a virus disease of the larvae. Fortunately, the disease is still active at the low population levels that now prevail, and several imported parasites are also proving helpful as control agents. Several rodents, which prey upon the cocoons, are also very important control factors. Undoubtedly airplane spraying with DDT would be effective against this pest, for other sawflies are easily killed by aerial applications of DDT.

HEMLOCK LOOPERS

Lambdina fiscellaria fiscellaria (Guen.)
Lambdina atharsaria atharsaria (Wlkr.)

These two closely allied native insects are common throughout the eastern United States and Canada. Although they differ slightly in life history, they are so similar that one is often mistaken for the other. Infestations of L. fiscellaria fiscellaria have been reported from Manitoba to Newfoundland in Canada and from Wisconsin to Maine in the United States. Outbreaks of L. atharsaria atharsaria have occurred somewhat further to the south from Ohio to New Hampshire. There are no known outbreaks in northeastern United States now; but L. fiscellaria fiscellaria is present in outbreak proportions in northern Newfoundland and at two widely separated points in Ontario.

Hemlock is the favorite host plant of both species. L. fiscellaria fiscellaria defoliates balsam fir seriously too; and it feeds on a wide variety of softwoods and hardwoods, especially where they are associated with hemlock and balsam fir. The larvae are very wasteful feeders; they gnaw off only part of a needle or cut the needles off at the base so that they fall to the ground.

Both loopers are sufficiently numerous at times to kill a lot of trees. Complete defoliation of hemlock and balsam is usually fatal, although some trees can take up to 90 percent defoliation and recover. The latest heavy infestations in the United States have been outbreaks of atharsaria in Pennsylvania, Connecticut, and New Hampshire. Between 1949 and 1952, mature hemlock was killed on areas totalling about 1,000 acres in western Pennsylvania. Most of the hemlock in this area grows in scattered patches, making up 5 to 10 percent of the stand. In 1951, some 50 acres of hemlock were killed in eastern Connecticut; and several hundred acres in New Hampshire were sprayed for protection against the pest. In Canada, fiscellaria has been in outbreak severity for several years in northern Newfoundland where about 500,000 cords of pulpwood have been killed. The two small areas in Ontario have also suffered severely.

The larvae of both species are typical yellowish inch or span-worms that bear black markings. They grow to about 1½ inches long.

L. fiscellaria fiscellaria overwinters in the egg stage, and the larvae hatch early in June; the moths are active in late August and September. Eggs are laid on the twigs and needles. L. atharsaria atharsaria overwinters as

PENNSYLVANIA DEPARTMENT OF FORESTS & WATERS PHOTO

A hemlock stand in Pennsylvania that has been defoliated by hemlock loopers.

a pupa just beneath the top layer of leaf mold. Moths of this species are active in May and June and the loopers feed from mid-June until late September.

The great rapidity with which infestations develop and decline indicates that natural factors are important

control agents. The Canadians have released parasites of closely allied western species in the East. Airplane spraying with DDT at the rate of 1 pound in 1 gallon of fuel oil per acre was an effective method of control in New Hampshire in 1951. Sprays were applied when the larvae were about half grown.

LARCH SAWFLY

Pristiphora ericksonii (Htg.)

The larch sawfly, which is found in Europe too, has been active on this continent since the beginning of the 19th Century, and some entomologists believe that it may be native here. Several great outbreaks have practically wiped out the mature larch in eastern Canada and the United States. Outbreaks have been active in northern Minnesota since about 1949. There have been none in the Northeast in recent years.

The larvae feed only on larch. They feed in clusters in the needles, completely stripping the foliage as they move along. In heavy outbreaks they work remarkably fast; often they defoliate a stand completely within 30 days. As a rule, young vigorous trees can withstand at least three successive years of heavy defoliation. Although mortality is negligible in young stands, growth loss is considerable.

The larvae are black-headed, the body grayish in color above and paler beneath. Full-grown larvae are about 3/4 inch long. The adult females are about 3/8 inch long, black with a wide orange band around the abdomen. The life history of the sawfly is so similar to that of other sawflies that no special description is necessary. One generation is bred annually. The insect overwinters as a cocoon in the duff.

The possibility of using biological-control methods is being studied intensively. The pest was apparently brought under control in Canada by the introduction of a European parasite in 1910 and 1911. Unfortunately, the early and startling success of this work has not lived up to later expectations, because the sawfly has apparently developed a resistance to the parasite. This seems to be unique. There are other valuable parasites, though; and rodents prey on overwintering cocoons, particularly in well-drained swamps. The possibility of using water levels in swampy terrain as a means of control is also being explored, because it has been found that cocoons are killed by submergence for limited periods. DDT sprays applied by airplane will almost certainly give satisfactory control.

LARCH CASEBEARER

Coleophora laricella (Hbn.)

The larch casebearer has long been recognized as a serious forest pest in Europe. It was first recorded in the United States in 1886. Latest reports indicate that it has spread to just west of Minneapolis and Port Arthur. In Canada outbreaks have occurred at about 7- to 9-year intervals; the last outbreaks were in 1947 in Nova Scotia, 1946 in Quebec, and 1952 in New Brunswick. A heavy outbreak occurred in Maine in 1949.

Eastern, European, and Japanese larch are all used by this insect as host trees. Upon hatching, the larva bores directly into a needle, feeding inside as a miner until late summer; then it constructs a case by cleaning out the mine and lining it with silk. The case enlarges as the larva grows; and the larva carries the case about on the hind part of its body. It mines new needles without leaving its case.

It is unlikely that extensive mortality will ever result from casebearer damage alone, because larval feeding is completed before the foliage is fully developed. Nevertheless, feeding causes serious reduction in height and diameter growth.

The adult is a delicate little moth, silvery to grayish brown; it has narrow wings fringed with long hairs. The larva is about 3/16 inch long, brown with a black head. The case is light grayish, and cigar shaped.

There is one generation annually. Moths emerge from the last part of May to early July in New England. The tiny larvae are about one-third grown in October, when they attach their cases to the twigs for the winter. They resume activity as soon as the foliage develops in the spring, and complete their feeding by the end of May.

Outbreaks are usually brought to an end by starvation and biotic factors. A number of European parasites were introduced into Canada and the United States in the early 30's, and two species have proved very effective. One of them (Agathis pumilus) has spread from a small liberation made in 1937 near Ann Arbor, Mich., throughout the whole Lower Peninsula; and it seems to be exerting significant control. The other species (Chrysocharis laricinellae) is the dominant species in other areas. Birds are important predators in certain circumstances, and a small Mirid preys extensively on the eggs.

Chemical control, using lime-sulfur spray applied against the larvae in the spring, is effective; but it would not be practical under forest conditions.

ARBORVITAE LEAF MINERS

Argyresthia thuiella (Pack.)
Argyresthia freyella (Wlshm.)
Recurvaria thujaella (Kft.)

Three species of arborvitae leaf miners are common in the eastern United States and Canada. Occasionally they become epidemic. As a rule all three species are found in close association, although one species usually predominates locally. In 1949, heavy infestations caused severe browning of white-cedar throughout central Maine and New Brunswick. This condition persisted through 1951 but terminated abruptly the next year.

Arborvitae is the principal food plant, although eastern red-cedar and southern white-cedar are also attacked. The larvae might more properly be called leaf and twig miners, because each larva mines many of the scale-like leaves and surfaces of the branches. The leaves are thus hollowed out; and, since the mines extend along the main branches, the whole leaf is killed. Heavy feeding results in extensive browning of foliage and eventual defoliation. Many trees died in the 1949-1951 outbreak in Maine, but probably most of them were also subjected to other unfavorable conditions. It is questionable whether the insects often kill vigorous trees.

The larvae of all three species are typical caterpillars. They are 1/8 to 1/4 inch long, yellowish or grayish white in color, with brown or blackish heads. All three species spend the winter in silk-lined portions of their mines. Pupation occurs in the spring and moths emerge from May until July. Eggs are usually laid in the axils of the branchlets.

Biological factors are important in controlling this pest. Parasitism was high in New Brunswick in 1950 and very high in 1951. Experiments conducted there indicated that DDT and lead arsenate applied between June 20 and July 10 at 5 pounds per 100 gallons of water gave satisfactory control. Airplane spraying tests using DDT and chlordane against the larvae in Maine gave only fair results. It should be kept in mind that mite infestations frequently follow the use of DDT on the cedars.

FOREST TENT CATERPILLAR

Malacosoma disstria (Hbn.)

Outbreaks of this native defoliator of northern hardwoods occur at about 10-year intervals, and they usually affect tremendous areas. We have just experienced spectacular outbreaks throughout Ontario, Quebec, and New York state. They started about 1948. In this country a peak was reached in 1954 when forests on about 15 million acres in New York, most of Vermont, and about 20,000 acres in Maine were from lightly to heavily defoliated. Marked reduction in the infestation occurred throughout the whole region in 1955, and it is anticipated that this trend will continue in 1956.

Poplar is perhaps the favorite food plant of the forest tent caterpillar; but they also feed heavily on maple, oak, birch, and other deciduous trees. The caterpillars are gregarious until nearly full grown, and during molting periods or in cold weather they congregate in large masses on the tree trunk or beneath large branches.

Repeated defoliation may result in extensive tree mortality and even one stripping may be serious. This has been particularly true of sugar maple in the Northeast. There has been considerable killing of tree tops and even entire stands in sugar maple orchards in Vermont when defoliation coincided with periods of drought. General surveys in Minnesota after the outbreak in the 30's indicated that 20 to 80 percent of the trees in the heavily infested areas were killed.

The full-grown caterpillar is about 2 inches long. The head and body are generally pale bluish in color and there is a row of keyhole-shaped white spots along the back. The moths are light buff in color, with a wing expanse of 1 to 1½ inches. The egg masses encircle twigs. They are cylindrical, and cut off sharply at each end. Each mass contains 100 to 350 eggs cemented together and covered with a shiny glue-like substance.

There is one generation a year. The winter is spent in the egg stage, and caterpillars hatch in April at about the time buds are bursting. Development is completed late in June and moths are active in July.

Natural factors eventually cause outbreaks to collapse, usually after 3 or 4 years of infestation. Numerous parasites and a wilt disease help. One of the important parasites, a Sarcophagid fly, is often so abundant that it actually seems to be a nuisance. Large acreages have been successfully sprayed with DDT from the air at the rate of 1

A mass of forest tent caterpillars on a tree trunk. This pest has done much damage to sugar maple in the Northeast.

pound of DDT in 1 gallon of fuel oil per acre in New York and Vermont.

SADDLED PROMINENT

Heterocampa guttivitta (Wlkr.)

The saddled prominent ranges from eastern Canada south to Florida and west to Colorado. Local outbreaks have been recorded throughout the East at approximately 10-year intervals since 1907-10. The latest hot spot is in the Berkshires in New York and Massachusetts. In 1954, an aerial survey by the New York Conservation Department revealed about 4,000 acres of defoliation on the New York side and 2,000 acres on the Massachusetts side of the state line. This area increased somewhat in 1955. About 20,000 acres on October Mountain in the Berkshires of Massachusetts are infested now.

Beech and sugar maple are preferred hosts, but the insect also feeds on birch, oak, and other hardwoods, especially where growing with beech and maple. Well-stocked

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Larvae of the saddled prominent, which gets its name from the saddle-shaped marking on its back.

NEW YORK CONSERVATION DEPARTMENT PHOTO

stands are usually attacked, and complete or nearly complete defoliation may occur. The pest probably is seldom responsible for killing trees by itself, because outbreaks are generally of short duration; but loss in growth results from defoliation.

The full-grown larvae are about 1½ inches long, bluish green to yellow in color, and have a reddish brown or purplish patch on the back, which somewhat resembles a saddle.

The moths emerge in late May or early June. They are strong fliers. Females lay up to 500 eggs singly on the leaves; larvae appear the first part of June. Feeding is completed in July and pupation takes place in the ground. The insect overwinters in the pupal stage. There is usually only one generation a year in this region.

As a rule, natural control factors eliminate outbreaks rapidly. Pupae are preyed upon extensively by parasites, rodents, and other predators. The State of New York is using DDT applied from airplanes to control the present outbreak, and Massachusetts will probably spray affected areas in 1956.

GYPSY MOTH

Porthetria dispar (L.)

The gypsy moth is common throughout Europe and Russia. It is also present in Japan. The story of its introduction into Massachusetts in 1869 is so well known that it need not be repeated here. The generally infested area in this country now includes New England and southward to the northeastern border of New Jersey and Pennsylvania. The insect is also present in two isolated areas; one near Scranton, Pa., and one near Lansing, Mich.

The gypsy moth is now at a low ebb throughout most of the generally infested area. This situation, though, follows an unprecedented high of 1½ million acres defoliated in 1953. Large-scale spraying operations were carried on in 1954-55, and mortality through natural control factors was heavy.

Gypsy moth caterpillars feed on a wide variety of trees and shrubs. They especially favor oaks, birches (except yellow and black), larch, linden, willow, poplar, and apple. When larvae are partly grown they feed on pine, hemlock, and spruce too.

This is not a winter scene. This oak forest in eastern Massachusetts has been stripped naked by the gypsy moth. The photo was taken in June.

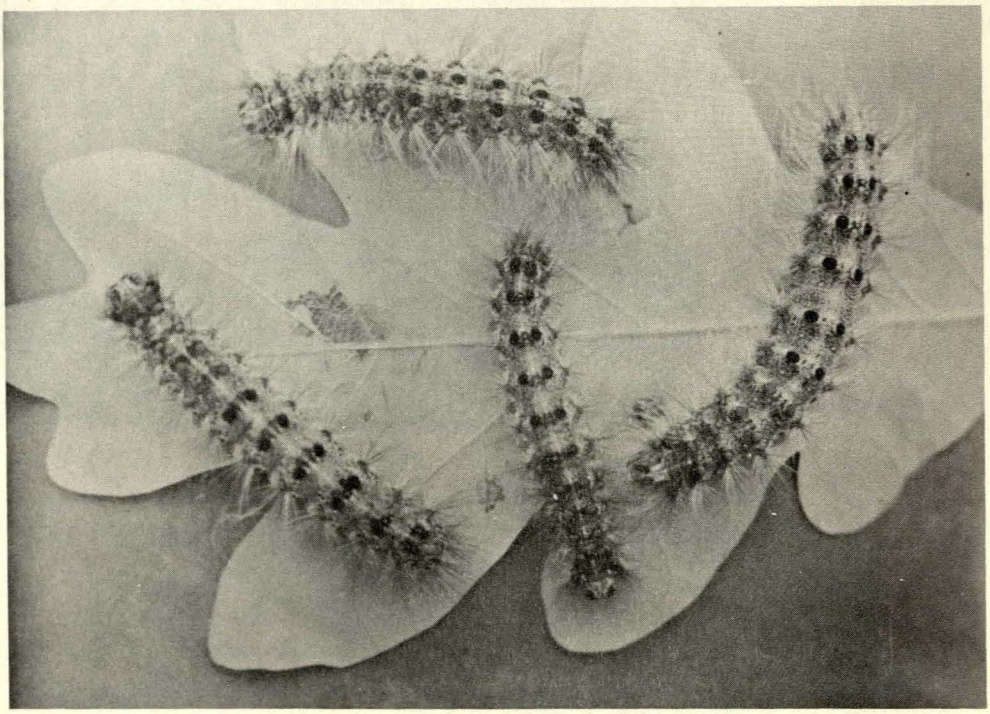
The susceptibility of a forest stand to gypsy moth attack and damage depends not only on the abundance of favored foods, but also on site and stand conditions. Dry sites--especially where land abuse is common--suffer more severe and more frequent outbreaks than well-managed stands. Killing is largely confined to the oak and pine oak types, and there is little mortality of oak unless successive stripping occurs. Hemlock and pine, though, may be killed in one season. It has been estimated that tree mortality and growth losses totalled about 6½ million dollars during the period 1933-52.

The mature larva is a hairy caterpillar 1½ to 2½ inches long. On the back there is a double row of five pairs of blue spots followed by a double row of six pairs of

red spots. The eggs are laid in masses of about 400, which are packed in yellowish hairs from the female moth's abdomen.

There is one generation a year. The insects overwinter in the egg stage. As soon as warm weather arrives the caterpillars hatch and start to feed. They complete their development early in July; then they pupate. The moths emerge a couple of weeks later.

Natural control factors help considerably to keep the gypsy moth in check. Several important parasites have been successfully introduced from Europe, and a wilt disease



Larvae of the gypsy moth, one of the Northeast's most costly insect pests.

kills both larvae and pupae. Natural control here is probably comparable to that in Europe.

The gypsy moth is easily controlled by chemicals. Almost complete elimination may be obtained by airplane spraying, using 1 pound of DDT in 1 gallon of spray per acre. Forest-management measures that improve stand and site help in control by creating conditions that are unfavorable to gypsy moth buildup.

A red pine stand that has been defoliated by pine loopers.

PINE LOOPER

Lambdina atharsaria pellucidaria (G. and R.)

The pine looper is another subspecies that is similar to the hemlock loopers. It is well distributed along the Atlantic Coast from Cape Cod to Florida. Local outbreaks have been recorded on pitch pine on Cape Cod at approximately 10-year intervals since 1913. This past summer the pest was in outbreak stage on the Cape; heavy infestation was reported from Delaware; and heavy feeding took place on a watershed planting of red pine near New Haven, Conn.

The preferred hosts are pitch pine and the southern pines, but the looper also feeds on red pine, hemlock, and

other conifers. Pitch pine can stand a lot of feeding, but occasionally this pest is abundant enough to defoliate trees so severely that they die. Approximately 35 acres of 25-year-old red pine have been killed on the property of the New Haven Water Company during the last 2 or 3 years.

The insect has nearly the same seasonal history as the hemlock looper atharsaria atharsaria. The loopers overwinter as pupae, and moths emerge and lay eggs in May and June. The larvae develop very slowly. They finish feeding in September, and then drop to the ground and pupate in the duff.

Little is known about natural control factors, but no doubt the overwintering pupae are preyed upon extensively by parasites and predators. Applications of DDT at the rate of 1 pound in 1 gallon of fuel oil per acre applied by helicopter gave complete control in the New Haven infestation last summer.

CANKERWORMS

Alsophila pometaria (Herr.)
Paleacrita vernata (Peck)

There are two species of cankerworms, the fall cankerworm (A. pometaria) and the spring cankerworm (P. vernata). Aside from slight differences in life history they are almost indistinguishable. They occur generally throughout the eastern part of Canada and in the United States as far south as North Carolina, and they have also been found in California. During the last few years defoliated areas of mixed hardwoods have been common throughout New England, the Mid-Atlantic States, and southern Canada. Street and parkway trees have also been hard hit. Local outbreaks occur all the time in one section or another.

Cankerworms feed on a wide variety of deciduous forest and shade trees; and since they are particularly fond of apple and elm, orchards and street trees suffer accordingly. A number of forest trees such as oak, hickory, walnut, cherry, ash, and birch are also suitable food plants. Damage is largely aesthetic, although defoliation invariably results in loss of increment and vitality.

Larvae of both species are typical inch, or measuring worms. They vary in color and may be pale green, dark brown, or nearly black. They usually have pale whitish lines running lengthwise of the body, but these may be broken or indistinct. The female moths are grayish brown, about 3/8 inch long, and wingless.

The fall cankerworm spends the winter in the egg stage. Eggs hatch in the spring, and the tiny larvae prefer the small tender leaves at the tips of the branches. The larvae become full grown in about 6 weeks, drop to the ground, and pupate in the soil. Adults emerge in November or December or even the following spring, and the females (which are wingless) crawl up the trees and lay their eggs.

The spring cankerworm moths usually emerge in the spring. Otherwise the life history is like that of the fall cankerworm.

Natural control factors must play an important role in the sudden extremes of abundance and scarcity reported for these species. Winter mortality of eggs and egg parasitism are often heavy. Cankerworm larvae are easily killed by spraying the foliage with insecticides. Care should be taken to spray early in the spring before the damage is done.

ELM LEAF BEETLE

Galerucella xanthomelaena (Schr.)

The elm leaf beetle is of European origin. First found in this country more than 100 years ago, it is now distributed from coast to coast. It is not a serious pest in woodlands, but it is of great importance as a defoliator of shade trees, particularly since it has become important to keep elms healthy and vigorous against Dutch elm disease. Heavy defoliation takes place annually throughout the range of elm in this country, although conditions fluctuate locally.

This insect prefers European elm, but attacks all elms. Both adult beetles and larvae feed upon the foliage; the larvae confine their feeding to the lower surface of the leaves. Of course elms are weakened by heavy feeding and defoliation, but they probably are seldom killed by the beetles. In an economic sense, though, the pest is tremendously important, for it is the pest against which most municipal spray work is done in the East.

The beetle is about 1/4 inch long, yellowish to olive green in color, with black stripes along the edges of the wings. The young larvae are black. Full-grown larvae are about 1/2 inch long, yellow with two black stripes down the back.

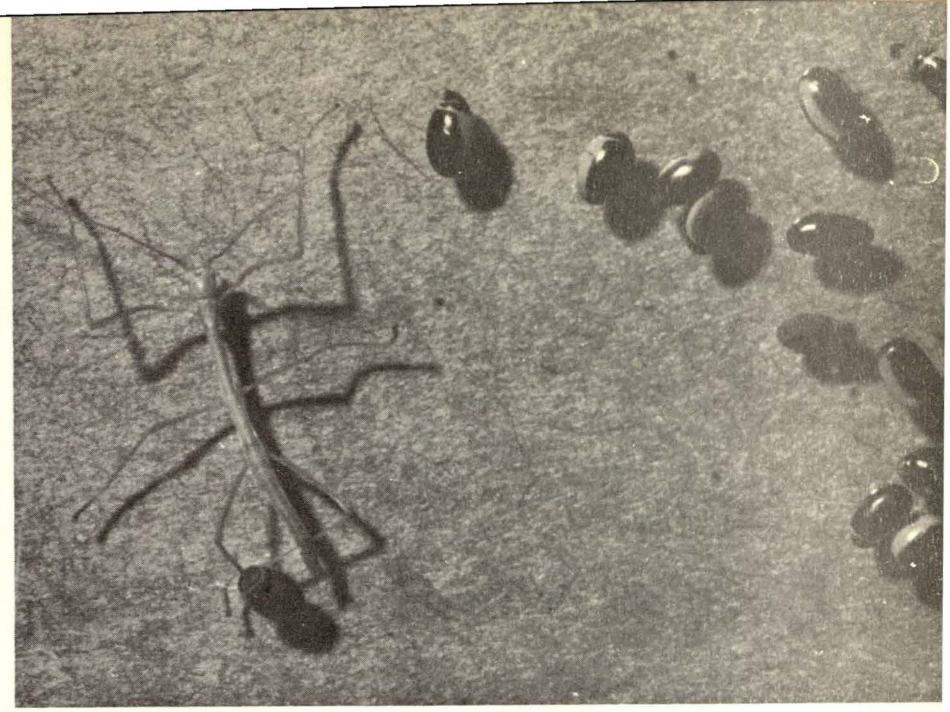
Adult beetles overwinter in dry sheltered places such as old barns and attics. They come out when the new foliage

appears. Egg-laying commences in late May or June and larval development takes 2 or 3 weeks. The larvae pupate in crevices in the bark or at the base of the tree, and the adult beetles emerge in about 10 days. In the Northeast there may be one or two generations a year; farther south there may be a partial third.

A native pupal parasite, Tetrastichus brevistigma Gaham, is sometimes effective in the Northeast, and it has been successfully colonized in California. Attempts to establish European parasites in the East have been unsuccessful; but a parasitic fly, from France, Erynnia nitida, has been established in California and attempts are now being made to colonize it in the vicinity of Washington, D. C.

The elm leaf beetle is easily controlled with lead arsenate or DDT, but when the latter is used special efforts must be made to control mites, which frequently follow DDT applications.

The walkingstick is one of those insects to whom Nature has given protective shape and coloring. It prefers oak leaves for its food.



The eggs of the walkingstick look like black beans.

WALKINGSTICK

Diapheromera femorata (Say)

This odd-shaped insect is fairly common in the eastern part of the country. Occasionally it becomes epidemic. In 1952, about 1,000 acres were defoliated in western Maryland and southern Pennsylvania, but that outbreak has by now declined. Large areas in the Lake States are sometimes affected. In 1951 about 1,000 acres were defoliated near South Bend in southern Ontario.

The walkingstick prefers oaks for food, but it feeds on other hardwoods too.

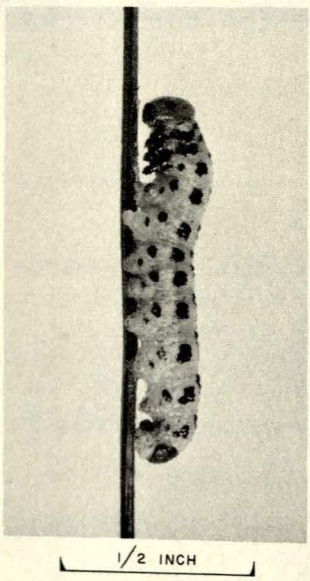
Full-grown walkingsticks are up to 3 inches long. As their name implies, they resemble twigs. They are wingless, have long slender bodies and long slender legs. The young are pale green, the older stages are gray or brown. Their eggs are black and hard-shelled, and they look like beans. There is usually a 2-year life cycle. Adult females drop their eggs to the ground in late summer, and the eggs overwinter one or two winters before hatching. Young nymphs commence feeding on the foliage in the spring, but develop rather slowly.

Climatic conditions are very important in holding walkingsticks at low levels. If there is insufficient moisture, a large proportion of the eggs fail to hatch. Spraying with DDT is effective.

PINE SAWFLIES

Pine sawflies have attracted a great deal of attention during the last few years. Several species are involved, some native and some imported. Some of the native species have been almost unknown until recently.

Perhaps the best-known native species is the redheaded pine sawfly Neodiprion lecontei Fitch, which is a serious pest of hard pines throughout eastern North America. It prefers young trees and is therefore most destructive in forest plantations. Local and widespread outbreaks began to occur when pure stands of pine were planted extensively throughout the eastern half of the country; and persistent heavy local outbreaks continue where young plantations are numerous. Red pine is preferred in the Northeast and Canada, jack pine in the Lake States, and shortleaf in the South; but in all regions the available hard pine is attacked.



Larva of the pine sawfly *Neodiprion lecontei*.

This past summer Virginia pine was severely defoliated by Neodiprion pratti pratti Dyar over a wide area in Maryland. Heaviest feeding occurred in the Patuxent River drainage. For the past 3 years loblolly pine on the Eastern Shore of Maryland and in Virginia has been heavily fed upon by Neodiprion taedae taedae Ross. Neodiprion nanulus Schedl. is an important pest of red pine, particularly in Quebec and Ontario. Neodiprion banksianae Roh. is a serious defoliator of jack pine in the Lake States.

There are in the Northeast three rather important species of pine sawflies that originated in Europe. The most important is Neodiprion sertifer Geoff.: it attacks red, Scotch, jack pine, and a few others. This pest has now spread beyond the Mississippi River and has defoliated large acreages of forest plantations. Diprion simile Htg. is now well distributed throughout the Northeastern States. It prefers white pine and other five-needled pines. It has caused considerable damage in Canada and the Lake States, but so far it has been confined to ornamentals and nurseries in the Northeast. Diprion frutetorum F. feeds principally on red and Scotch pines; and feeding has been heavy in some plantations in Connecticut.

All of these sawflies are similar; in fact, the adults are very difficult to distinguish. They are heavy, thick-bodied, 4-winged flies about 3/8 inch long, usually black with yellow markings. The full-grown larva range from 3/4 to 1 inch in length. They are usually yellowish or greenish with blackish strips or rows of black spots.

All these species have similar habits. As a rule the larvae feed gregariously at first, and they prefer the old growth. They usually develop very quickly, completing their feeding within a few weeks. When abundant, they strip the old foliage from the tree in remarkably short time. As a rule, though, they avoid the current foliage, and it takes several successive strippings to kill a tree. When feeding is completed, the larvae drop to the ground and spin cocoons in the duff at the base of the tree. There are from one to three generations a year depending upon climate. Adults may emerge in late summer and lay eggs that overwinter in the needles (sertifer, pratti pratti, taedae taedae, nanulus, and banksiaenae), or they may overwinter in the cocoon stage (lecontei, simile, and frutetorum).

There are a number of natural control factors that help to keep the pine sawflies in check. Many parasitic enemies and rodents prey heavily upon the cocoon stage. Lately a virus disease of sertifer has been used to excellent advantage as a spray against that species. There is evidence that the other sawflies may be affected by similar specific diseases. A virus of pratti pratti has already been found effective. Sawfly larvae may be easily controlled with DDT sprays.

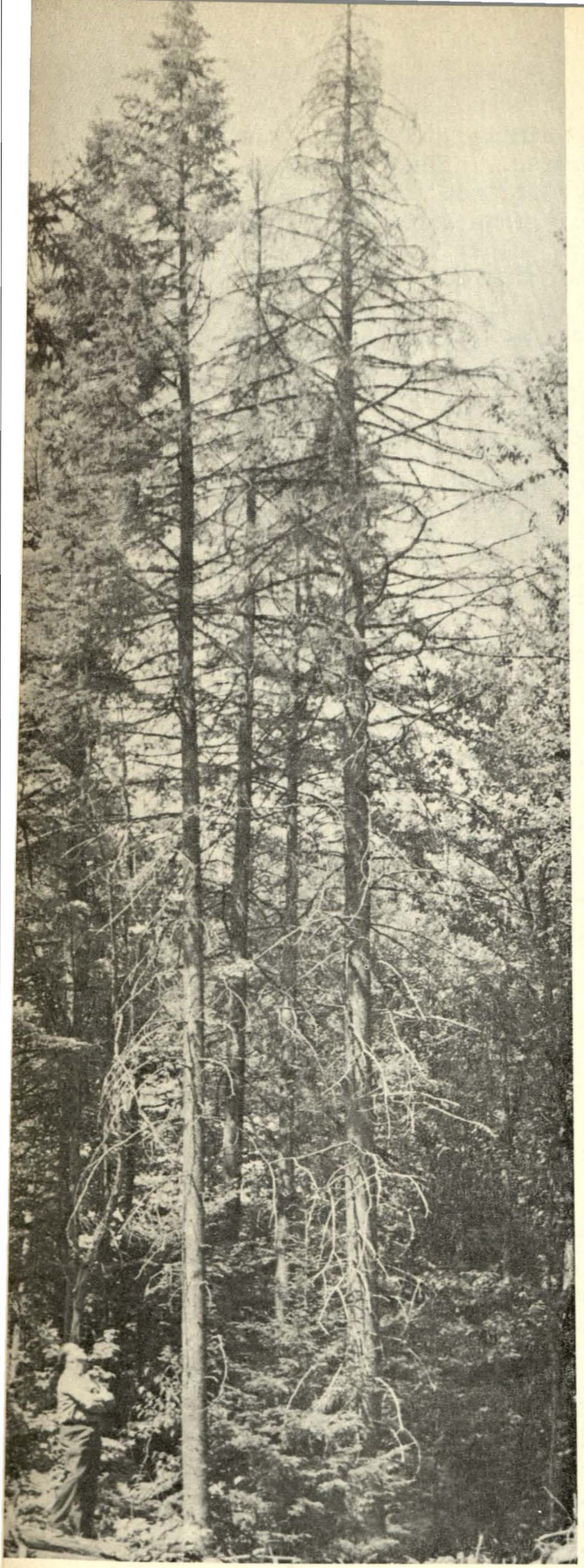
SUCKING INSECTS

BALSAM WOOLLY APHID

Adelges piceae (Ratz.)

The balsam woolly aphid is probably of Asiatic origin. It arrived in North America from Europe some 60 or 70 years ago. At present it is distributed generally throughout the northeastern part of the United States, Nova Scotia, Prince Edward Island, and the southern half of New Brunswick. It has also been found on true firs in the Pacific Northwest.

Firs (Abies spp.) are the only known hosts. The minute insect attacks all age classes of trees by inserting its long beak into the bark, injecting a hormone-like sub-

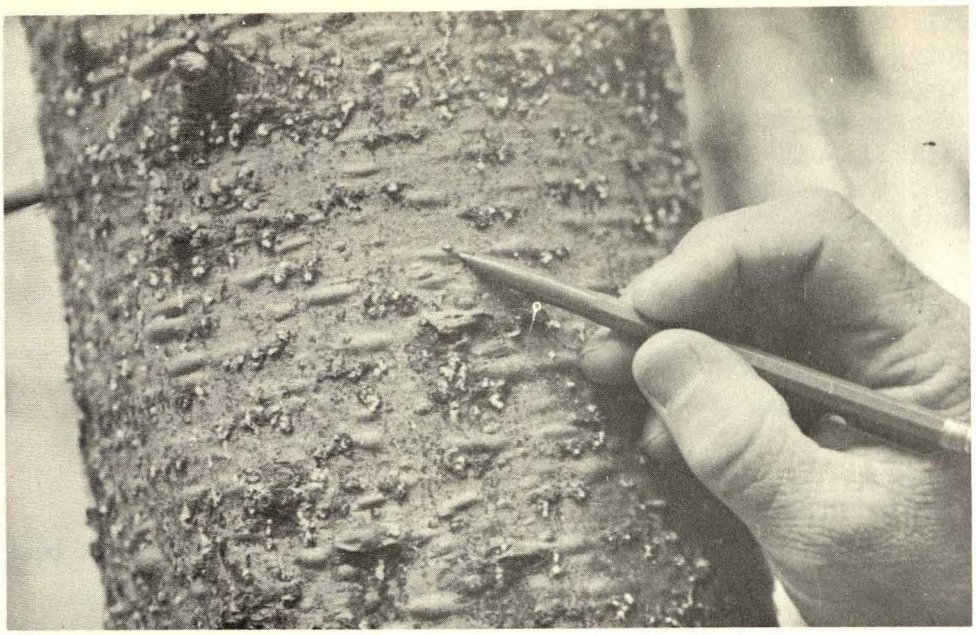


stance, and sucking juices from the living bark tissue. The injections kill and distort the surrounding tissue. Heavy attacks interfere with conduction and respiration, and the trees soon die. Twig and bud attack results in gout-like swellings, loss of new buds, and gradual death of twigs and tree tops. Balsam fir reproduction is severely damaged.

Tree mortality caused by the balsam woolly aphid is seldom spectacular, because trees are usually killed singly or in small patches rather than simultaneously over large areas. However, the annual loss is high. It is the most serious insect enemy of balsam fir in the Northeast--with the possible exception of the spruce budworm.

Although tiny, the balsam woolly aphid is easily identified by its white woolly secretions. In heavy infestations, the bark may be almost completely white. There are two generations annually; the winter is spent as a tiny first instar. Feeding is resumed very early in the spring and the adult stage is reached during May, when egg-laying begins. Newly hatched larvae are active and crawl about rapidly. They insert their stylets and settle down. Another generation is completed in the fall. Young larvae from this generation overwinter.

Balsam fir trees killed
by the balsam woolly aphid.



The balsam woolly aphid is one of the tiny sucking insects. The aphids inject a hormone-like substance into the bark and suck juices from the living tissue.

Several natural factors help control the insect. Temperatures of -30° F. cause high mortality, and several predators feed on the aphid. A predaceous fly, introduced from Europe several years ago, is generally distributed throughout New Brunswick and Maine and it has been released recently in Vermont and New Hampshire. Several species of predaceous beetles are now being introduced into Canada from Europe. Two of them were supplied for colonization in Vermont and New Hampshire this past season. A number of contact insecticides give excellent control of the aphid, but their application is not practical under forest conditions.

Since the insect generally builds up first on the older and larger trees, balsam fir stands should be operated on as short a rotation as possible to minimize damage.

BEECH SCALE -- NECTRIA COMPLEX

Cryptococcus fagi (Baer)
Nectria coccinea var. faginata

The beech scale-nectria complex is an outstanding example of teamwork in killing a tree. Neither organism will

kill the tree by itself; yet together they destroy one of our important forest trees. Both were apparently introduced into Nova Scotia from Europe before 1900. Since then they have spread throughout most of New England and as far as the Catskills in New York, and there seems to be nothing to prevent their eventual spread throughout the natural range of American beech.

The beech scale and Nectria attack American and European beech of all sizes. All parts of the bark, from exposed roots to the under side of the upper branches, may be affected. The scale inserts its beak into the bark and

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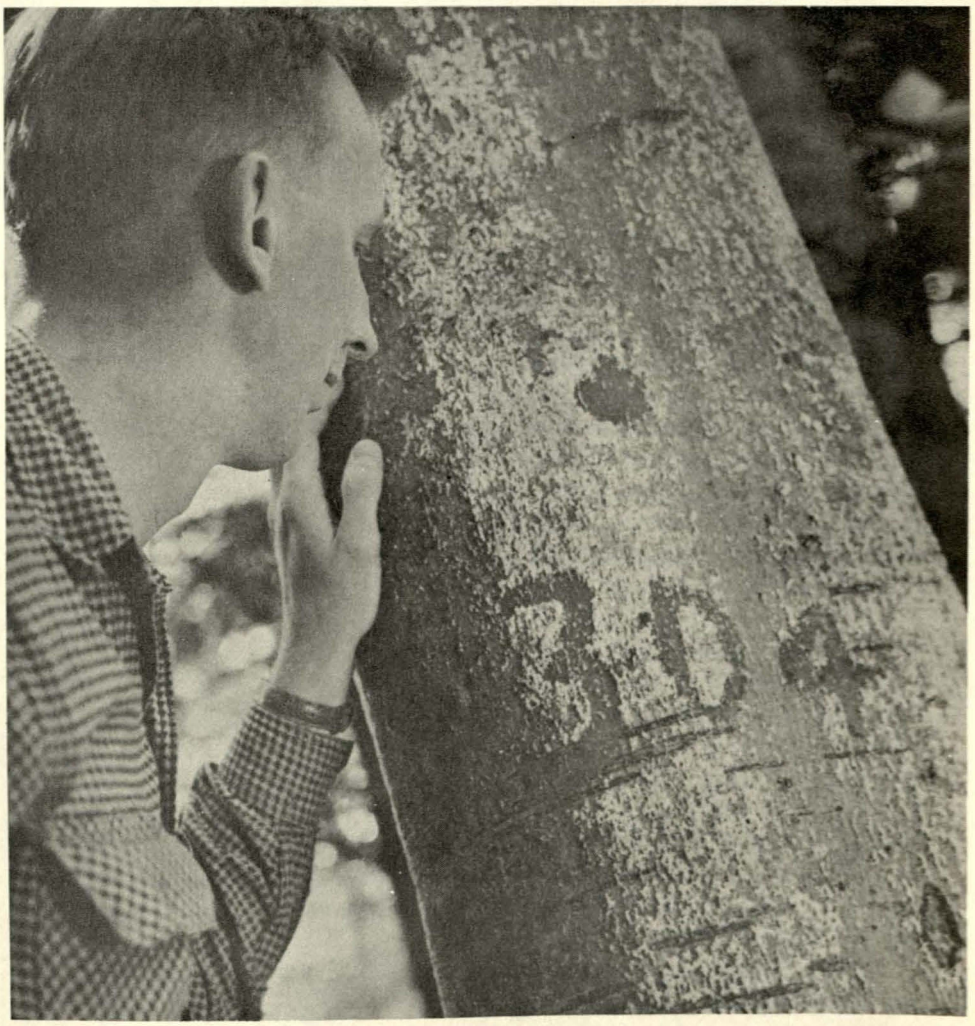
A beech tree infested with beech scale. The number had been put on with paint before the scale attacked the tree.



sucks up the plant juices. As a result the bark dries and cracks, leaving openings through which the Nectria fungus gains entrance. Once the fungus is established, it rapidly kills the area of bark previously occupied by the scale. As the dead areas coalesce the tree is girdled and dies.

The beech stands of Nova Scotia, New Brunswick, and Maine have already suffered heavy mortality; serious mortality in the White Mountains of New Hampshire has been occurring for several years; and this past summer some dead trees were observed in Vermont. Trees are also dying in the Catskills. It has been estimated that more than 50 percent of the beech in the Maritime Provinces and eastern Maine has been killed by the beech scale-nectria complex.

The mature beech scale is only 0.5 to 0.8 mm in diameter. It is covered with a white woolly coat of waxy secretion. It is inconspicuous until the individual white specks coalesce into streaks and patches. In heavy infestation, the bark may seem to be covered with a felt-like coat. The scale is unable to exist on dried-out bark, so it disappears before Nectria fruiting bodies appear. They are tiny, red, lemon-shaped bodies about the size of a pin head. They appear in clusters and may be dense enough to color patches of the bark bright red.

There is one generation of the beech scale each year. Reproduction occurs parthenogenetically. The scale spends the winter as a tiny nymph that has already settled down with its beak inserted through the bark. It resumes activity in the spring. Egg-laying commences about June 15 and reaches a maximum in July. Crawlers are abundant during August and September. Wind dispersion during this stage is probably the chief way the insect gets spread around.

Low temperatures and a predaceous lady-bird beetle kill large numbers of scales, but they are ineffective in controlling it. The beech scale can be controlled with insecticides, but under forest conditions chemical control is impractical. Studies in forest management are under way to determine if regulation of the density of forest stands will affect buildup of scale infestations. At present, however, the only recommendation that can be made is to cut a heavily infested stand before the trees begin to die.

PINE LEAF APHID

Pineus pinifoliae (Fitch)

The pine leaf aphid occurs throughout southern Canada and the northern half of the United States. At present there is a heavy outbreak in New England and New York.

. In the Northeast, eastern white pine and red spruce are the insect's alternate hosts. In the West, several species of pine and spruce are attacked. On spruce the nymphs attack the needles, causing terminal galls that have the appearance of cones. On white pine the new shoots are attacked. Damage on spruce is probably of little economic importance except where aesthetic values are important--as with Christmas trees. On pine there is sometimes extensive damage to twigs.

The pine leaf aphid has alternate hosts: it spends one year on white pine, the next on red spruce. *Left*, the aphids on white pine needles. *Right*, on spruce the aphids cause a gall that looks like a spruce cone.

During the current outbreak many small pines have been killed, particularly in plantations; and some good-sized natural-grown pines have also been killed. In New Brunswick, where severe damage to white pine has occurred every other year since 1947, a 60-percent loss of growth in alternate years has resulted.

In heavy infestations adult aphids are conspicuous, for they attach themselves to pine needles in rows, one behind the other with their heads all pointing toward the base of the needle. They have black heads and whitish wings. The immature stages cover themselves with a white flocculence.

The aphid has a complex 2-year life cycle. The winter is spent as a nymph. On pine the nymphs are found on new growth. When they finish feeding, adults emerge and migrate to red spruce. Eggs are laid at the base of the spruce needles; and feeding causes the formation of compact terminal galls that look like true cones. An aphid develops in each chamber of the gall. These open in June of the following year, and adults emerge and migrate to pine. Here they attach themselves to the needles and give birth to a new generation of nymphs, which overwinter on the pine.

Chemical control had not been considered practical until recently. This past season, however, the New York State Conservation Department successfully treated 227 acres by using a mist blower. Several areas were sprayed with nicotine sulphate and two areas with lindane. The Vermont Agricultural Experiment Station has had good success using miscible oil applied at the time the nymphs move to the new growth on pine.

PIT-MAKING OAK SCALE

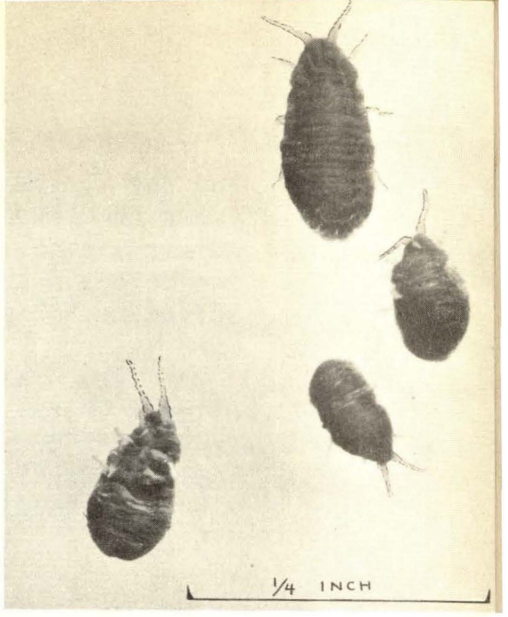
Asterolecanium minus (Lind)

The pit-making oak scale is probably of European origin. It is present over most of the world where oaks occur, and is well distributed throughout the United States. It is known to attack English, chestnut, and white oaks. In the Northeast chestnut oak is the most severely attacked. A recent outbreak has occurred in Pennsylvania.

Like other scale insects, this pest inserts a stylet in the bark and feeds upon the plant juices. Feeding causes considerably more damage, though, than the mere removal of cell contents, for the tissue around the insect proliferates to form galls or swellings. Where there are as many as 50 scales per square inch on branches 1/4 to 2 inches in diameter, the whole branch usually dies. Reproduction is most seriously affected, but large trees are often killed too, especially if the trees are weakened by other factors such as drought. During the last few years mortality of chestnut oak in Pennsylvania was prevalent; and it was almost certainly associated with heavy scale infestations.

An undamaged stand of red pine before being attacked by the Matsucoccus scale. (This is near an infested area.) This pest, discovered only a few years ago, has attacked red pine in Connecticut and Long Island.

The picture below shows how a red pine stand looks after it has been killed by the Matsucoccus scale. The inset *(right)* shows a close-up of this sucking insect.



There is only one generation a year in the Northeast, and the winter is passed as an adult scale. Production of young is distributed over a considerable period during the summer months. The young usually crawl about for a day or two before settling down to feed. Once the stylets are inserted in the plant tissue the insect never moves again.

The scale is often heavily parasitized by Habrolepis dalmani Westw., and shipments of this tiny parasite to New Zealand in the 20's probably helped in controlling the scale there. Control with insecticides is impractical under forest conditions.

MATSUCOCCUS SCALE

Matsucoccus resinosae (B. and G.)

Matsucoccus resinosae is a new species, possibly of foreign origin, found only in a relatively small area in Connecticut and New York. First discovered in 1946, it is, as far as we know, confined to approximately 100 square miles in the two states; and probably no more than 500 acres are infested. Surveys conducted during the past 5 years indicate a spread of only 1 or 2 miles a year.

Until this summer, red pine (Pinus resinosa) was the only known host of the scale. However, this past season it was reared at the Boyce Thompson Institute on Japanese red pine (Pinus densiflora S & Z) and Chinese pine (Pinus tabulaeformis C.)

Red pine of all ages is killed by Matsucoccus. The first symptoms of damage appear when heavily infested branches are killed. The foliage first turns yellowish and later brick red. Usually the pest multiplies so rapidly that the entire tree is killed within 3 or 4 years after the initial attack. Since 1946 about 100 acres of red pine have been killed in Connecticut and considerable mortality has occurred on estate and ornamental plantings on Long Island.

Matsucoccus is a typical soft-bodied scale insect. The females are wingless and look like little pigs, but the males are delicate black flies with long filament-like setae at the apex of the abdomen. The females cover their egg masses with white waxy filaments, and the male pupae are covered with the same sort of cottony material. These white cottony masses are often the most conspicuous evidence of an infestation.

There are two generations a year. The winter is spent as a nymph, which completes development early in June. Females lay about 300 eggs. The heaviest concentration of scales occurs on limbs and branches. Often these branches have several hundred scales per square inch. The insect is probably spread, in the crawler stage, by the wind.

A number of natural control factors occur but none is effective. During the winter of 1953-54, temperatures of -15° F. killed a high proportion of the overwintering nymphs in the vicinity of Bridgeport, Conn. A number of predators have been observed. Several chemicals have been tested, but none has proved to be entirely satisfactory. Thus far, chlorothion is the most promising.

The pine spittle bug is a common native insect that protects itself with a glob of spittle. In severe outbreaks they may kill trees.

PINE SPITTLE BUG

Aphrophora parallela (Say)

The pine spittle bug is a native insect that is distributed generally throughout eastern United States. It is a common and conspicuous insect and is locally abundant in some areas in the Northeast at present.

Its principal host plants are Scotch, white, pitch, and jack pine. It also attacks red pine and occasionally Norway spruce. Feeding habits are remarkable in that the nymphs cover themselves with a froth or spittle and live within this protective covering until the adult stage. Newly hatched nymphs insert their beaks just behind a bud and suck the plant juices. They may move around on the twigs, forming new spittle masses as they go. When they become full grown they migrate to the stem and feed gregariously under large spittle masses. The adults do not form a spittle mass, but they eject undigested sap in the form of a mist which is similar to a light rain in heavy infestations. The adults feed upon twigs and branches and probably do considerably more damage than the nymphs. Heavily infested branches and twigs are killed and in severe outbreaks Scotch pine trees have been killed in 2 or 3 years.

The adults are boat-shaped and about 3/8 inch long, light brown and dotted with pale and dark spots. The winter is spent in the egg stage at the base of the terminal buds. Hatching takes place in early May. Feeding is completed in July and the nymphs leave the spittle mass and migrate to the needles where they transform to the adult stage. There is one generation a year.

Natural enemies help to keep the pest in check, a parasitic fungus being one of the most important. DDT sprays applied against the adult stage would undoubtedly give good control of this insect. One pound of DDT in one gallon of spray per acre has given good control of the Saratoga spittle bug, a closely related species.

TWIG AND TERMINAL FEEDERS

WHITE PINE WEEVIL

Pissodes strobi (Peck)

The white pine weevil is a native insect that is found throughout the entire range of eastern white pine. It is the most serious insect pest of this valuable tree. In the Northeast a high proportion of the trees in open-grown

natural stands and in plantations have been attacked one or more times by the pest.

White pine is the favored host, but Norway spruce is also severely attacked. Other trees frequently attacked are jack pine, pitch pine, and red spruce.

The larvae feed in the preceding year's leader, boring beneath the surface between the bark and outer wood. Usually they feed gregariously, forming a ring around the leader, and bore downward. The leader is killed as well as the current growth. So at least two, often three, and occasionally four years' growth is killed. Usually a lateral branch takes the place of the dead leader, causing a crooked tree to develop. Sometimes two laterals will develop, causing a forked tree.

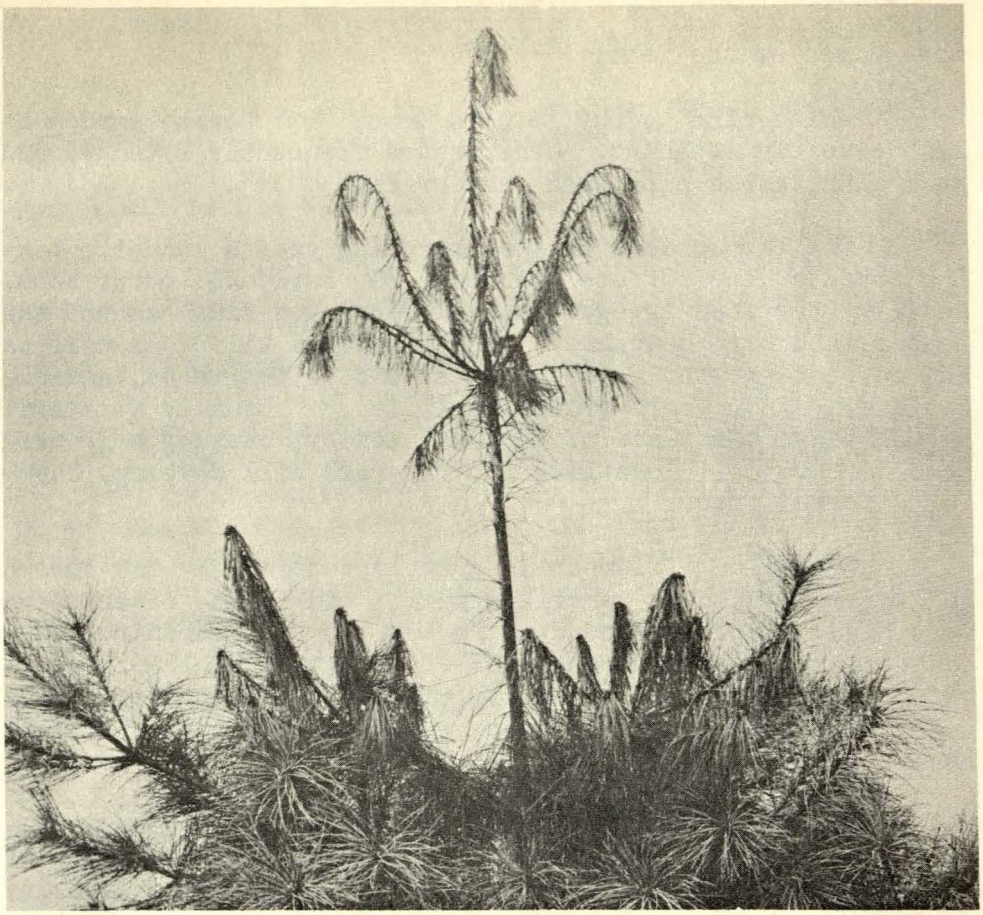
The value of lumber is greatly reduced by the crooks and forks caused by weevil attack; and volume losses are very high. Studies conducted in 1952 in New Hampshire indicated an average volume loss of 13 percent in pole-size timber, 40 percent in the sawlog portion of sawtimber trees, and 70 percent in the portion above sawlog limits of merchantability in sawtimber.

The adult weevil is an elongate brownish snout beetle, 4 to 6 mm. long, marked with irregular small patches of grayish white and yellow scales. The pearly white eggs are about 1 mm. long. The larvae are white, cylindrical, and footless. The pupae are creamy white.

The winter is passed in the adult stage in the litter beneath the trees. Activity begins in late March. Eggs are laid in small punctures in the bark of the leader, and they hatch a week or 10 days later. During the latter half of July the larvae become full grown and pupate. Some adults emerge in late July, others do not appear until fall.

Insect parasites and predators, as well as birds, destroy a great number of weevils, but not enough to effectively control this pest.

Small areas of young trees may be protected by spraying the leading shoot with a concentrated lead arsenate or DDT spray with a knapsack sprayer, before eggs are laid in the spring. Aerial spraying of large plantations with heavy dosages of DDT offers promise for control. The most satisfactory results have been obtained with a helicopter using a spray dosage of 2 pounds of DDT in 2 gallons of liquid per acre. Airplane spraying, using 4 pounds of DDT in 4 gallons of liquid per acre, is also effective.



The wilting leaders of this white pine tree tell that it has been attacked by the white pine weevil, the most serious insect enemy of this valuable species.

When white pines grow in mixtures with hardwoods and are overtopped, weevil damage is much less than in open-grown stands. This offers a clue to the control of the weevil through forest management.

NANTUCKET PINE TIP MOTH

Rhyacionia frustrana (Comst.)

The Nantucket pine tip moth is widely distributed from Massachusetts south to Florida and west to Texas. The pest seems to be constantly in outbreak stage somewhere

The white pine weevil attacks spruce too. See the weeviled leaders on this Norway spruce.

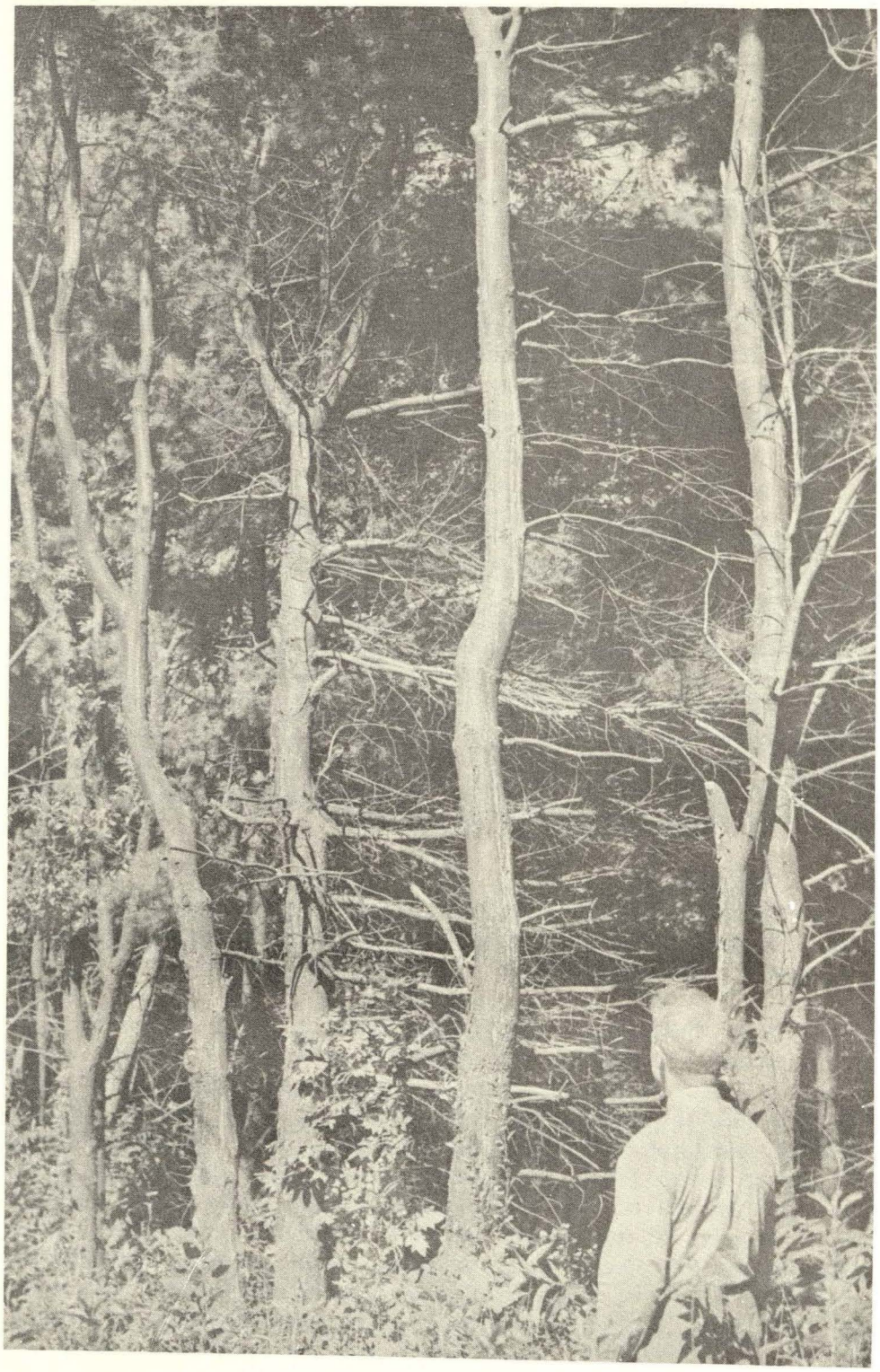
within its range. It attacks shortleaf, loblolly, pitch, and several other hard pines heavily, but slash and longleaf seem to be exceptions. The feeding larvae kill shoots by boring within the buds and the shoot itself.

The tip moth is a serious pest of small trees. It seldom kills trees, but it deforms them and delays height growth. After the trees get to be about 25 feet tall they are not seriously injured.

The larva is yellowish to pale brown; so it is not apt to be confused with its close relative, the much darker European pine shoot moth larva.

To see how the white pine weevil affects the quality of white pine timber, notice the tall straight stems in this undamaged stand. Now look at the stand shown on the next page.

These white pine trees have been deformed by weevil attacks. When the weevils kill the leaders, the trees grow up crooked and forked.



In the Mid-Atlantic States the tip moth has two generations each year. It overwinters in the pupal stage and moths are active from mid-April to mid-May and again in late June and early July. Eggs are laid on needles, buds or shoots; and upon hatching the larvae feed at the base of the needles or buds. They soon spin a protective web, which becomes covered with pitch; and then they bore directly into the shoot or bud where they complete their development and pupate. Farther south there are three and even four generations a year.

There are a number of tip moth parasites, but they seem to be ineffective for control. Insecticidal control is extremely difficult and at present is considered impractical in forest stands. Plantations, nursery stock, and ornamentals may be protected by spraying at the rate of 1 pound of DDT per 100 gallons of water. At least two sprayings are needed each season. They should be applied in May and in July when the first and second brood moths are laying eggs.

EUROPEAN PINE SHOOT MOTH

Rhyacionia buoliana (Schiff.)

The European pine shoot moth is a native of Europe and Asia, being found wherever the host species of pine occur. It was apparently introduced into this country a few years before 1914, when it was first reported attacking ornamental Scotch pine on Long Island. Since that time it has spread from Massachusetts south to Virginia and west to Illinois and Michigan in the United States, and from Nova Scotia to British Columbia in Canada.

Red and Scotch pine are attacked severely, but many other species such as Austrian, mugho, ponderosa, loblolly, and jack pine are also attacked. White pine is seriously attacked in Europe but not in the United States.

Upon hatching, the young larvae bore into the base of the needles. Later in the summer they leave the needles and bore into the developing buds. Trees are seldom killed, but feeding causes permanent deformities of the leader or the lateral branches. It is a very serious pest in plantations, attacking trees from the time they are 1 or 2 feet tall until the crowns of the trees close. On young trees in some areas almost every shoot may be infested, and frequently plantations are completely ruined. The pest is so serious on red pine in portions of the Northeast that this tree species is no longer recommended for planting.

The adult is a rusty red-orange moth with irregular transverse silvery bands and whitish legs. When full grown, the larvae are 5/8 inch long and brown in color with a black thorax and head.

The insect overwinters as a partially grown larva in a shoot. Development is completed the following spring and pupation takes place within the infested shoot. There is only one generation a year.

The larval form is susceptible to a temperature of -10° F. or lower, and winter mortality is effective in keeping the population at subepidemic levels in the northern portions of its range. A number of European parasites have been liberated and at least three species have been established in this country; but they have not proved very effective.

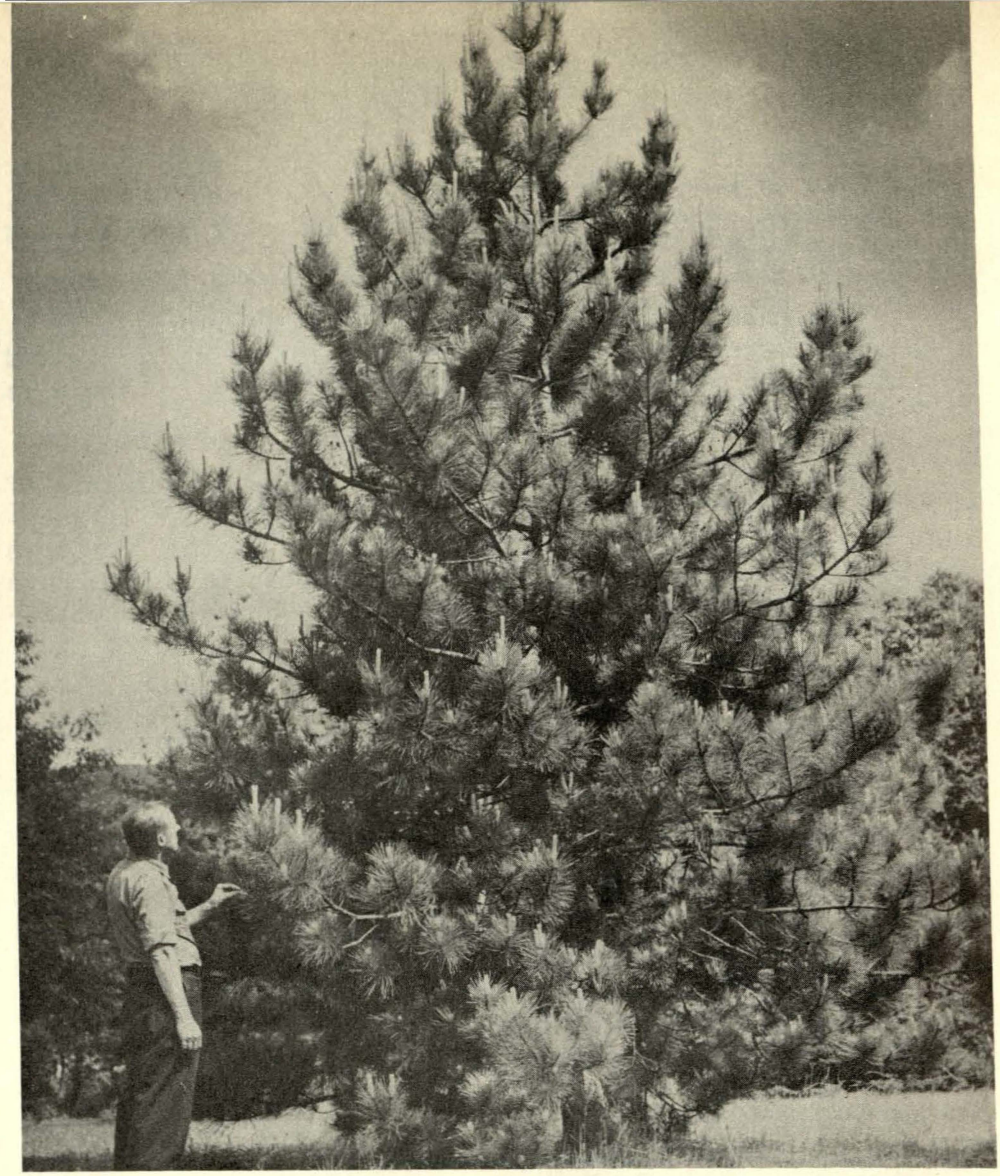
Chemical control of this insect has not proved practical to date, but extensive tests are now being conducted with the new systemic insecticides, and some look promising. Where plantings, nurseries, or ornamentals are of sufficient value, 8 pounds of lead arsenate or 8 pounds of derris in 100 gallons of water (with sufficient sticker) are effective if the timing of the application is right. Heavy DDT sprays are also effective. Spray should be applied about the time that the young needles are half as long as the old needles, which coincides with the egg-laying period of the moths. Thorough coverage is essential. On individual ornamental trees or in nurseries, control may be obtained by removing and destroying infested shoots in the spring before or during the pupation period of the insect.

BARK FEEDERS

PALES WEEVIL
Hylobius pales (Hbst.)

The Pales weevil is a native insect. Its range is the entire eastern half of the United States and adjacent parts of Canada. This insect is the outstanding insect enemy of white pine reproduction in the Northeast, but it also attacks red pine and other conifers.

Injury is caused by the adults feeding on the bark of seedlings and the twigs of larger trees. The weevils frequently girdle and kill seedlings. Feeding is done mostly at night; and on seedlings the weevils feed from the ground



This tree shows the normal healthy growth that can be expected from red pine. But the species has a bad enemy: the European pine shoot moth. The next picture shows what it can do to red pine.

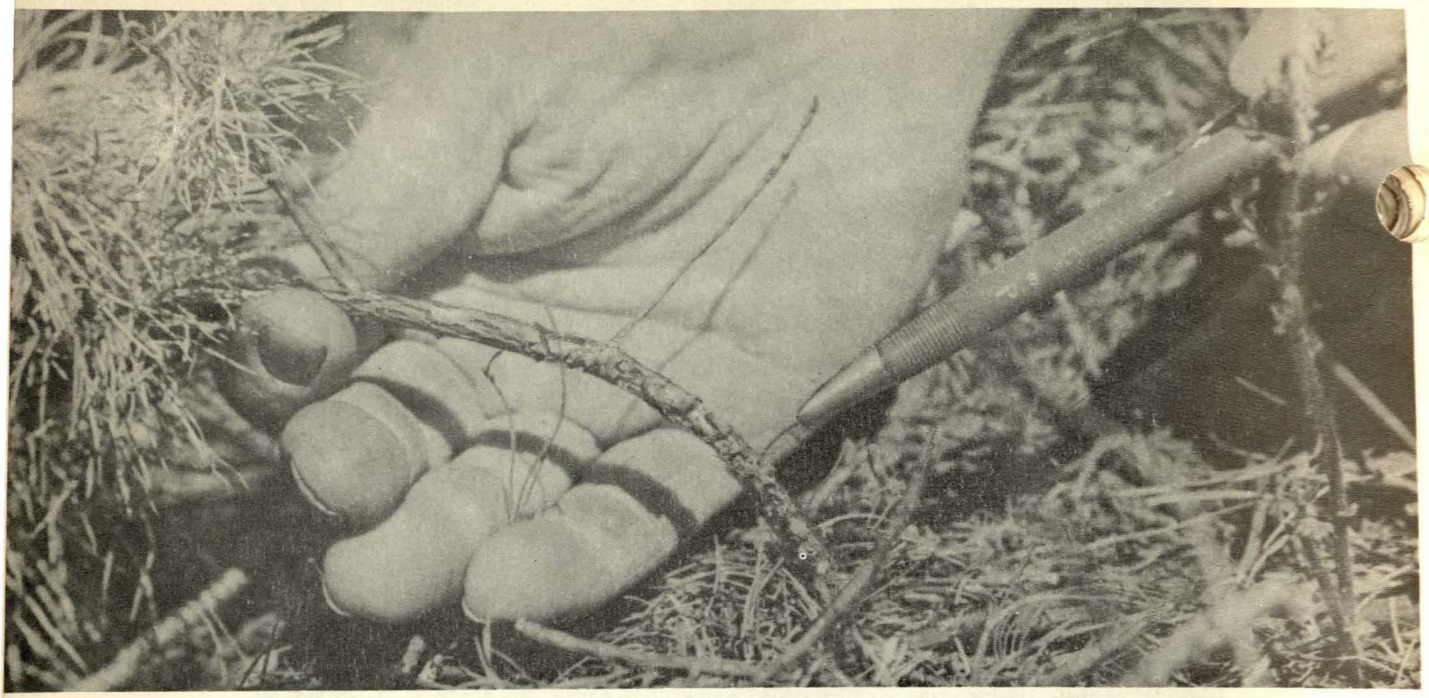
line upward. So severe is the damage caused by this insect that it is impractical to plant until at least 2 years after a cutting operation or a fire. In many instances all reproduction has been killed by weevils after a heavy cutting.

The adult beetle is robust, dark reddish brown to black, 7 to 10 mm. long, and irregularly and sparsely marked with gray or yellowish hairs. In its natural habitat it is easily identified by its stocky appearance and stout cylindrical beak. The larva is white and footless. When full

Deformed, stunted, and scraggly, this red pine shows the damage that the European pine shoot moth does. The pest is so serious that red pine is no longer recommended for planting in some parts of the Northeast.

grown it is slightly longer than the adult.

The adults are strong fliers and are attracted by the odor of fresh pitch. They lay their eggs in late spring in the inner bark of cut logs or freshly cut pine stumps. Larval development takes place between the wood and the outer bark. The adults emerge in early fall and feed on the tender bark of seedlings. Most of the damage is caused at this time. The adults overwinter in the litter and emerge in May to feed for a time and then lay their eggs.



A white pine seedling that has been attacked by the Pales weevil. This bark feeder attacks white pine seedlings on areas that have been disturbed by fire or logging.

A fungus disease has been reported to be effective at times in reducing Pales weevil populations, but as a rule natural enemies seem to be unimportant as control factors. The adult insect may be controlled by chemicals. Both concentrated lead arsenate spray and DDT emulsion have proved effective. Seedlings may be sprayed in the seedbeds, dipped in bundles, or sprayed after planting.

Much can be done to control the Pales weevil through silvicultural practices. Light thinnings or shelterwood cuttings should be used to stimulate heavy reproduction. Reproduction of 10,000 or more trees per acre would leave a sufficient number of seedlings even if the Pales weevil killed up to 80 percent of the crop. If the second cutting is made in a seed year there should also be many 1-year seedlings that would escape weevil injury.

CONE AND SEED INSECTS

Most of the insects that do serious damage to cones and seeds of conifers are native species. They sometimes

destroy all of the seed crop of a tree species in a locality in one season or for an even longer period. A serious situation has developed in Maine, where almost total destruction of white pine seed for 3 or 4 years after the devastating forest fires of 1947 had greatly retarded reforestation.

Most of the damage is caused by three groups of insects: (1) cone beetles, (2) cone moths, and (3) seed chalcids. Each of these groups attack the cones and seeds in a rather characteristic way.

The cone beetles are small black or brown scolytid beetles closely related to the bark beetles and resembling them. In early spring they attack year-old cones, boring into the stem of the cone and forming a pitch tube. The beetles then mine down the axis of the cone, girdling it. This results in the typical stunted or "blighted" cone. As the females work down the cone, they lay eggs in niches along the sides of the mine. The small (1 to 2 mm.), white beetle grubs feed indiscriminately on scales and seeds. They pupate and become adults in the cone, where they stay until the following spring.

The cone moths attack partially grown green cones and also those killed by cone beetles. They lay their eggs on the cone scales; and upon hatching, the larva eats into the center of the cone where it feeds voraciously on scales and seeds. In some species there is a second generation that attacks full-grown cones. A portion of the larvae do not pupate immediately, but hibernate as larvae and pupate the next spring.

Seed chalcids are small hymenopterous insects. They deposit eggs directly into the developing seed by means of a long ovipositor. The larva feeds and completes its development within a single seed. The cones are uninjured, and there is no evidence of injury to the seed until the adult chalcid emerges.

Few attempts have been made in the Northeast to control these insects by means of chemicals, but benzene hexachloride applied in March and April has been found effective in the control of insects that attack the cones of longleaf pine in the South.

EASTERN SPRUCE BEETLE

Dendroctonus piceaperda (Hopk.)

The eastern spruce beetle is primarily a pest of mature and overmature spruce stands of the eastern United States and Canada. It becomes less important as the old original stands of spruce are harvested. All species of eastern spruce are susceptible; and mature and overmature trees--including living, dying, and recently killed trees--are attacked.

The beetles usually attack on the lower 30 to 90 feet of the tree, or to a top diameter of 7 to 8 inches. Injury to the tree is of two types. The larvae feeding laterally from many egg galleries girdle the tree. However, death of the tree is much too rapid to be blamed on mere girdling. Experiments with other species of Dendroctonus have shown micro-organisms introduced by the beetle interfere with the conduction of water through the sapwood.

This insect is considered the most serious bark beetle in the Northeast. An outbreak in 1897-1901 in eastern Canada and New England caused an estimated loss of more than 1 billion feet of fine spruce. The last extensive outbreak in the East occurred on the Gaspé Peninsula between 1931 and 1934. Tremendous mortality of spruce occurred, but there seems little doubt that many of the trees would have died anyway from defoliation by the European spruce sawfly, which was epidemic at the time. Certainly the beetle hastened tree mortality. In recent years the pest has caused severe mortality of old-growth red spruce in the Adirondacks.

The adult beetle is 1/4 inch long, cylindrical and thickset in appearance, and light brown to dark reddish brown or black in color. The larvae are small, curved, legless grubs with brown heads.

The adults emerge from the bark throughout the summer and attack nearby trees, entering through circular holes made in the bark. Characteristic pitch tubes are formed on the more vigorous trees. The beetles work in pairs, making tunnels upward between the bark and the wood; and the female lays her eggs along the edges of the tunnel. The larvae feed outward from the egg galleries. The insect overwinters in all stages and there is considerable overlapping of generations.

There are several predaceous beetles that feed on this insect, and woodpeckers take a heavy toll. Removal of mature and overmature stands before they are attacked is the most effective way to prevent a bark beetle outbreak.

BRONZE BIRCH BORER

Agrilus anxius (Gory)

The bronze birch borer is a native insect that is well distributed throughout the range of Betula species in the United States and Canada. It has been very prevalent in recent years in the Northeast, coincidental with the excessive dying of birches. With the improvement in the birch die-back situation, bronze birch borer populations have declined.

This insect attacks birches, especially the white and yellow species. The adults feed on the foliage of a number of other hardwoods, but cause no economic damage. The larvae feed in the cambium and adjacent phloem and xylem, frequently girdling the branch or stem.

Ornamental birches, fully exposed to sunlight, are often attacked and killed. Under forest conditions the borer is able to adapt itself to a considerable range of conditions, but there is doubt that it can successfully attack and kill trees unless they are greatly weakened or dying from some other cause. However, the attacks by this beetle greatly hasten the death of weakened trees.

The adult is a dark olive-bronze beetle about 3/8 inch long. The larva grows to a length of 1-5/8 inch and is creamy white with a flat prominent head. Larvae and their tunnels are easily seen by peeling away the bark.

Most of the beetles emerge from late June to mid-July. Eggs are laid in the bark in clusters, averaging six eggs per cluster. The eggs soon hatch and the larvae bore directly into the bark and feed in the cambial region, making winding tunnels up to 3 feet long. The insect overwinters in the bark, usually in the pupal stage. Development may be completed in 1 year, but generally a 2-year-life cycle is indicated.

Egg and larval parasites normally take a high proportion of the population. The Maine Forest Service reports that spraying with DDT in late June gives a high degree of control against the adults. To avoid damage by this insect, birch stands should not be opened up excessively; and if

partial cuttings are made, it is best to remove no more than one third of the stand at one time.

HEMLOCK BORER

Melanophila fulvoguttata (Harr.)

The hemlock borer is a native insect that is generally distributed throughout the range of eastern hemlock in the United States and Canada. The borer is causing little damage in the Northeast now.

Eastern hemlock is the principal host of the borer, but in rare instances it has been found breeding in spruce. Damage is caused by the larvae, which feed on the inner bark and cambium. The hemlock borer attacks trees that already have been weakened through drought, exposure, or defoliation. On severely weakened trees, larval feeding may cause girdling of the tree. Damage to decadent and dying hemlock on the Menominee Indian Reservation in Wisconsin a number of years ago was first credited to the borer; but investigations proved it to be of only secondary importance, and in no cases did it cause appreciable injury to vigorous trees.

This insect belongs to the flat-headed borer family. It is a rather small dark bronze beetle with three white to yellow spots on each wing cover. The larvae are white, legless, up to ½ inch in length, and have a flattened head or prothorax.

The adults emerge from the bark from the latter part of May until late in August. Eggs are laid in groups deep in the bark crevices, where they are firmly cemented. The young larvae penetrate the bark to the inner phloem--or on the weaker trees to the cambium--and make winding transverse tunnels. The insects overwinter in the bark as larvae or prepupae. There is generally one generation per year.

Control of this insect is best obtained by keeping trees in a healthy condition. Defoliators such as the hemlock looper should be controlled. Since hemlock is sensitive to exposure, cuttings must be carefully regulated.

ELM BARK BEETLES

Scolytus multistriatus (Marsh.)
Hylurgopinus rufipes (Eich.)

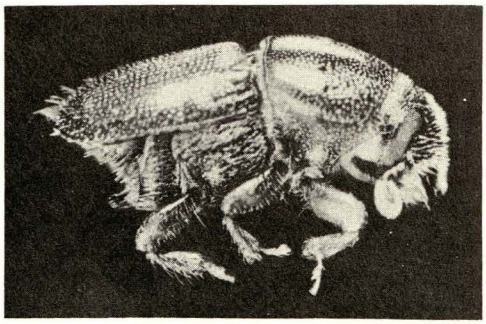
Those two beetles are important as the two principal carriers of the Dutch elm disease. The European elm bark

beetle (Scolytus multistriatus) is of European origin; whereas Hylurgopinus rufipes is a native insect. The European species is by far the more important carrier in this country, and it occurs throughout the Eastern States west to Colorado. Hylurgopinus is generally distributed throughout the region. It is the more important carrier in Canada, where Scolytus has only recently been found.

Scolytus confines its attacks to elms; and it has a definite preference for recently cut, dying, or weakened trees. The adults feed in the crotches of living elm twigs, and it is this habit that makes them such serious distributors of the disease--by themselves they would be of no economic importance. Hylurgopinus adults feed in the bark of the trunk or large branches of trees and breed in dead, dying, or recently cut elm wood.

Scolytus adults are about 1/8 inch long and brownish black in color. They have a noticeable spine projecting backward on the under side of the body. The larvae are legless white grubs. From one to three generations develop annually. The winter is passed in the larval stage in the bark. Development is completed in the spring, and adults emerge in mid-May through small round emergence holes which they cut in the bark. Emergence continues through the warm months. After a feeding period, the adults bore into the bark of recently cut or weakened trees and form their egg galleries in the inner bark. The eggs are placed in niches along the galleries, and the larvae mine out at right angles to the longitudinal galleries. When full grown, the larvae form pupal cells and transform into adults.

Hylurgopinus is a somewhat smaller brown beetle without the ventral spine. It has one or two generations a year, overwintering as either a larva or as an adult. Emerging young beetles fly to healthy elms and feed in bark tunnels before they seek a place to breed in. These feeding tunnels are in bark alone. For egg-laying, any dying elm limb 2



The elm bark beetle *Scolytus multistriatus*. This is the insect that carries the Dutch elm disease.

inches in diameter or larger seems to suit them. Egg galleries are of the transverse forked type, which readily distinguishes them from the longitudinal Scolytus galleries. Many of the overwintering adults bore into the bark of healthy elms to hibernate; and since they bore through to the wood, they doubtless transmit Dutch elm disease at this time. Both beetles attack diseased and weakened trees readily, and thus hasten spread of the disease.

The only known method of keeping elms free from bark beetle feeding is to keep the trees well sprayed with DDT. This is difficult and costly, but good results have been obtained from two thorough applications of spray: one about May 1, before the leaves appear; the other 2-1/2 to 3 months later. Mist-blower applications using 12 percent DDT are satisfactory. A miticide should be added to the DDT spray to prevent a buildup of mites or aphids.

Besides protective spraying, tree-sanitation programs are important. These include the prompt removal of diseased trees, the pruning of healthy trees to eliminate dead and dying wood, and protection against other insects such as elm leaf beetles and canker worms.

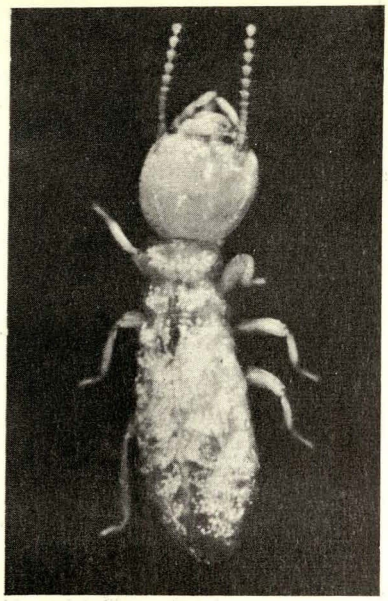
FOREST PRODUCTS INSECTS

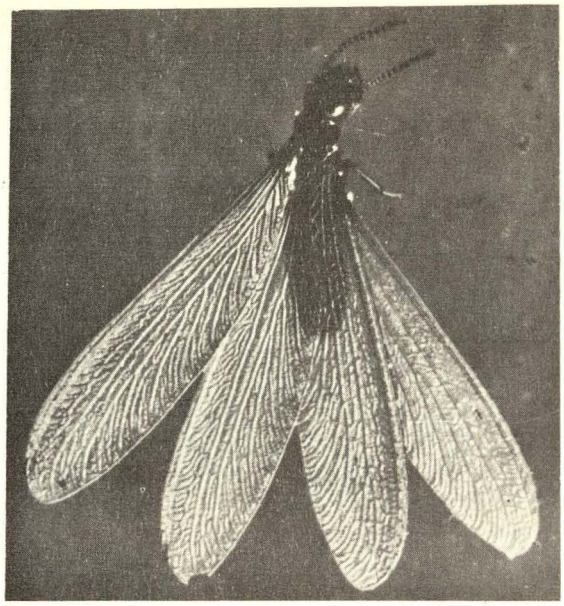
TERMITES

Reticulitermes flavipes (Koll.)

The eastern subterranean termite is found in the eastern half of the United States; in Ontario, Canada, Mexico, and northern Guatemala; and in some localities along the Mediterranean Sea in Europe, especially southern France. It feeds on wood and wood products and other items such as fabrics, fiber board, and the like that contain cellulose. Occasionally it attacks living trees, shrubs, flowers, and crops. Greatest damage is done to woodwork in buildings. In heavy attacks the wood is riddled with termite tunnels.

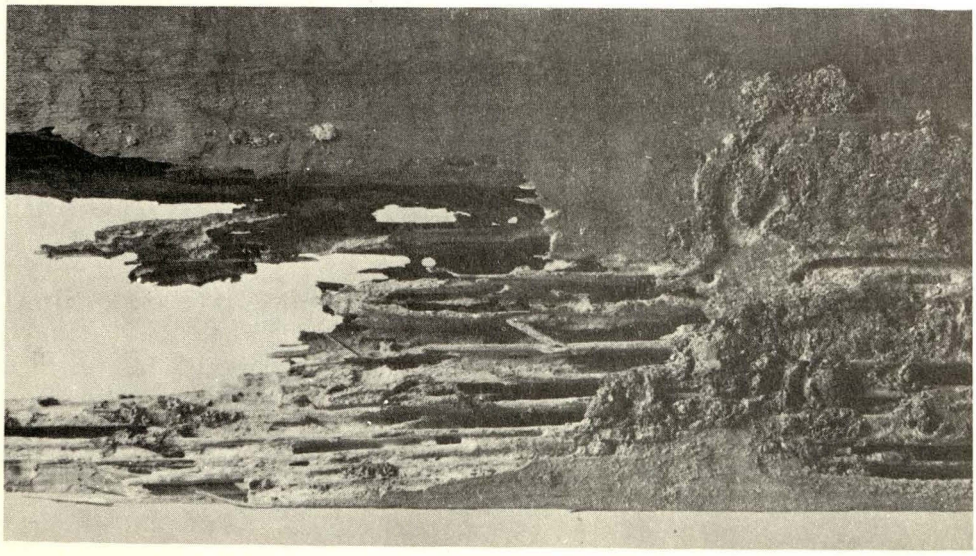
The termite colony is located in the ground, and these insects must have continual contact with the soil in order to survive. Where untreated woodwork in a building is in direct contact with the ground it is easy for termites to enter a building. But they may also make entry through cracks in the foundation or they may build earthlike shelter-tubes over foundation walls through which they travel back and forth from their colony. One of the most common areas of entry in houses is around door steps or attached porches.





The termite is a common pest of forest products. The specimen on the left is the worker: this is the stage that does the damage. The winged form on the right is the sexual adult that emerges from the colony in the spring.

A house timber that has been damaged by termites. Though it will attack living trees, paper, and other materials that contain cellulose, the termite does most of its damage to the wood in buildings.



Termites cause damage in this country that can be reckoned in millions of dollars annually. They are more active in the South, but also cause severe damage in the Northeast.

Colonizing flights of termites occur, most frequently, after the first warm days of spring. The individuals in these flights are winged adults that have developed in well-established colonies. Flights often occur within buildings. The adults soon shed their wings and most of them perish; but some pairs survive to start new colonies. The worker termites, which do all the damage, are about 1/4 inch long, grayish white, and blind.

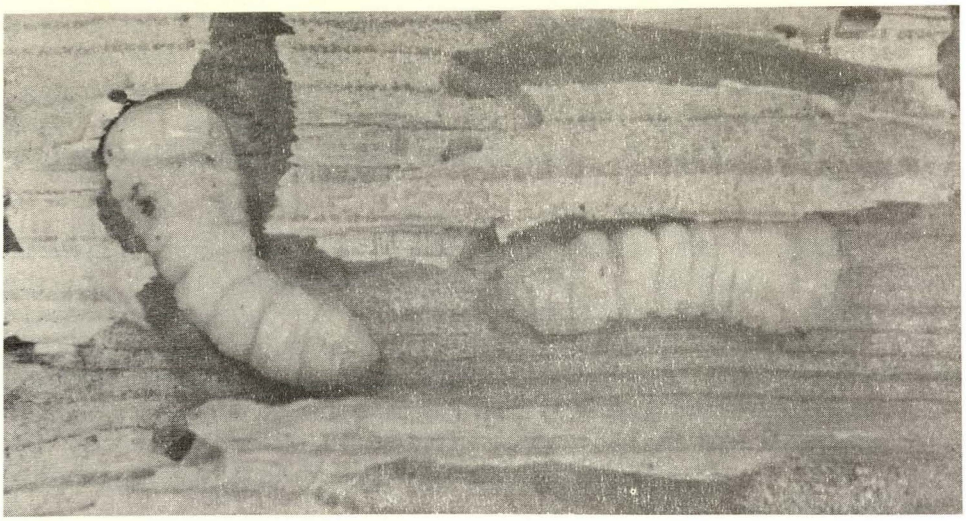
Much can be done to reduce damage by properly constructing buildings to prevent termite entry. Foundations and masonry porches should be constructed without cracks or voids. All woodwork in contact with the soil should be pressure-treated. A combination of structural changes to prevent entry and chemical treatment of the soil to kill the termites is the best way to combat an infestation in a building. Some of the new chemicals, such as chlordane, are excellent soil poisons and are effective against termites for at least 5 years. To apply a soil poison, a trench about $2\frac{1}{2}$ feet deep is dug along the exterior wall of the foundation, and as the soil is replaced it is treated with a 2-percent chlordane emulsion at the rate of 1 gallon per lineal foot of trench.

POWDER-POST BEETLES

Lyctus spp.

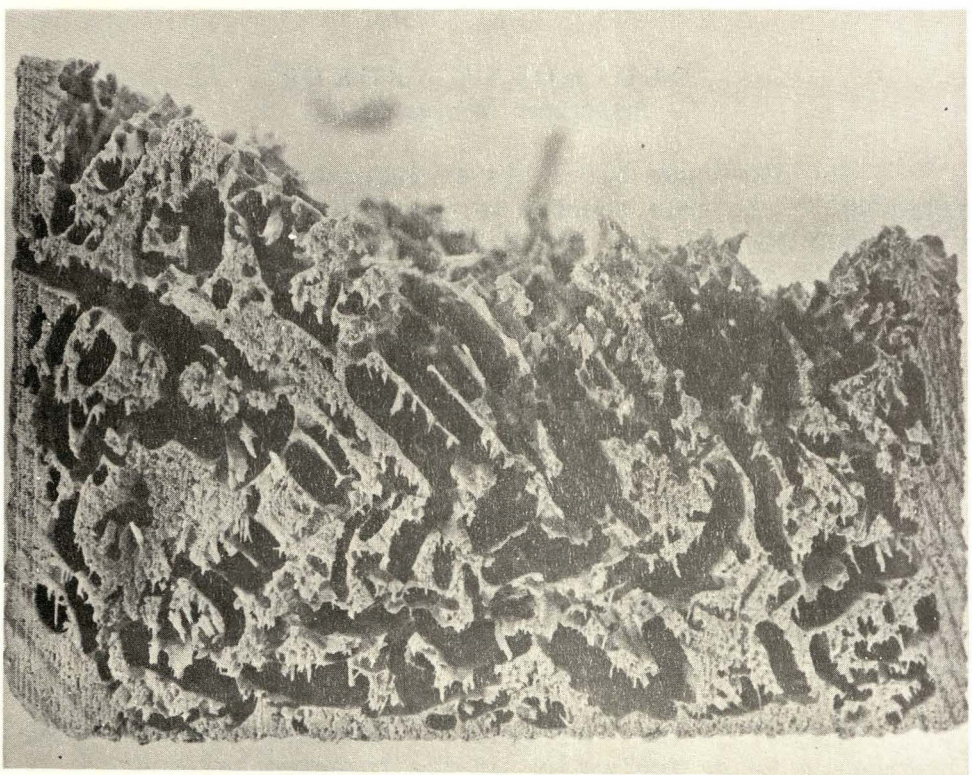
Powder-post beetles are distributed throughout the world and are pests of hardwoods and softwoods. Infestations begin any time after a tree is cut or is in the early stages of manufacturing. Completely seasoned wood in use for many years is still subject to attack unless properly protected. In the Northeast, powder-post beetles infest wood in lumber yards, processing mills, structural timbers in buildings, flooring, and furniture.

Different species of beetles infest different kinds of wood. Some of these pests infest hardwoods and others softwoods. In some instances bark is required; for others it is not. The incidence of attack by powder-post beetles is often related to the starch or cellulose content, moisture content, or porosity of the wood. Infestations are usually confined to the sapwood.



Larvae of the old-house borer, which feeds in the dry sapwood of softwood lumber.

Cross-section of a structural beam that has been riddled by the old-house borer.



The extent of damage depends much upon the proportion of sapwood in the infested material. Structural timbers cut from fast-growing second growth can be affected seriously. Because of the large amount of sapwood in lumber now being cut, material such as tool-handle stock is very susceptible to attack.

Many of the powder-post beetles have the ability to continually reproduce, generation after generation, in the same wood. Those that require bark for egg-laying remain active only until those areas containing bark have been destroyed. The life cycles of the different species of beetles differ in duration from a few months to a year. After the eggs are laid by the adult female on or in the wood, the major part of the insect's life is spent as a larva tunneling through the wood.

Lumber or rough-manufactured stock can be protected from attack by dipping the wood in one of the chlorinated hydrocarbon solutions. Active infestations--if not too far advanced--can also be controlled by treatment in the same manner. When lumber is in use, such as timbers in a building, the insects can often be eliminated by using spray or brush treatments of solutions that contain insecticides such as DDT, BHC, or chlordane. When the insects are feeding deep within larger timbers, however, fumigation of the building may be necessary to kill them.

OLD-HOUSE BORER

Hylotrupes bajulus (L.)

The old-house borer is a European species that was introduced into this country many years ago. It is present throughout most of the United States. This pest is apparently becoming more prevalent each year in the Northeast.

It feeds in the dry seasoned sapwood of coniferous lumber. Rafters and flooring in old buildings are sometimes so completely riddled that replacement of timbers is necessary. Sometimes buildings are rendered unsafe for occupancy.

The adult is a flattened slaty-brown beetle 10 to 20 mm. long. The larva is whitish, with a head wider than long. Adults appear in late summer and lay their eggs in checks and irregularities in the wood. The normal larval feeding period is probably about 3 years, but in many instances it may extend to 5 years or more.

Control is very difficult. In fact, the only positive method is by fumigation of the infested building.